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RECOGNISING ACHIEVEMENT

Friday 18 January 2013 – Morning

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes/Experimentation and Data Handling

Candidates answer on the Question Paper.
OCR supplied materials:
- Insert (Advance Notice for this question paper) (inserted)
- Data, Formulae and Relationship Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Ruler (cm/mm)
- Protractor

Duration: 2 hours

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **24** pages. Any blank pages are indicated.

SECTION A

1 Here is a list of combinations of base units of the SI system.

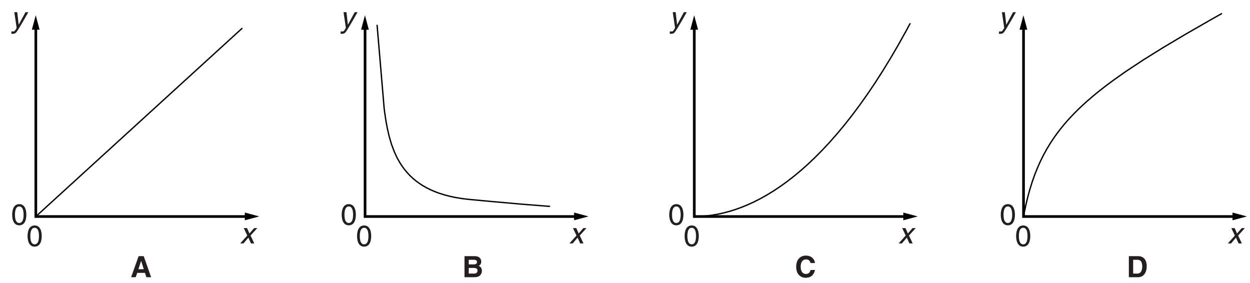
$kg\,m\,s^{-1}$ $kg\,m\,s^{-2}$ $kg\,m^{2}\,s^{-2}$ $kg\,m^{-1}\,s^{-2}$ $kg\,m^{2}\,s^{-1}$

Choose the combinations of units for

(a) kinetic energy .... **[1]**

(b) force. .... **[1]**

2



State which graph, **A**, **B**, **C** or **D**, best represents the relationship between the two quantities given in each case below.

(a) *y*-axis: the frequency of a wave
x-axis: the wavelength of that wave

.... **[1]**

(b) *y*-axis: the kinetic energy of a moving object
x-axis: the speed of that object

.... **[1]**

(c) *y*-axis: the speed of an object falling from rest on Earth, assuming air resistance is negligible.
x-axis: the time it has been falling

.... **[1]**

(d) *y*-axis: the speed of an object falling from rest on Earth, assuming air resistance is negligible.
x-axis: the distance it has fallen

.... **[1]**

3 Fig. 3.1 shows the velocity–time graph for the motion of a car.

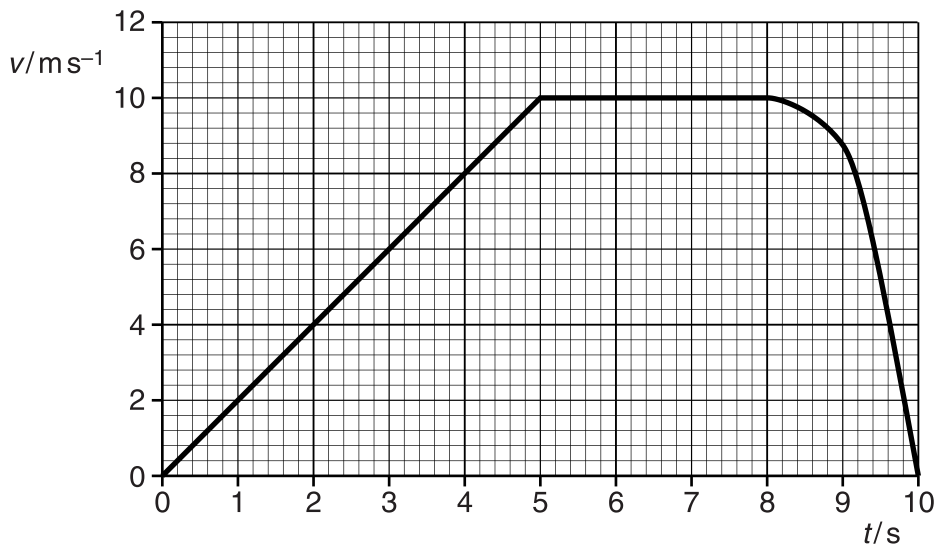


Fig. 3.1

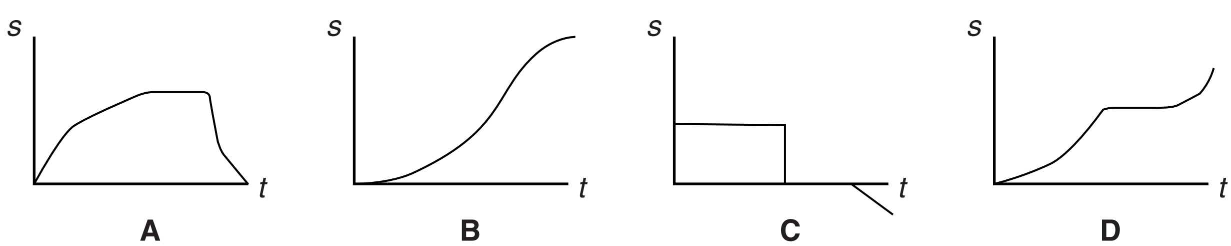
(a) Calculate the distance travelled by the car in the first 8 seconds.
You should show your working.

distance = ... m **[2]**

(b) Use the graph to estimate the deceleration of the car at $t = 9.0$ s.
You should show your working on the graph and in this space.

deceleration = ... m s^{-2} **[2]**

(c) Which sketch graph, **A**, **B**, **C** or **D**, best represents the displacement–time graph for this journey?



answer .... **[1]**

4 Fig. 4.1 shows standing waves of frequency 5.0 Hz on a string.

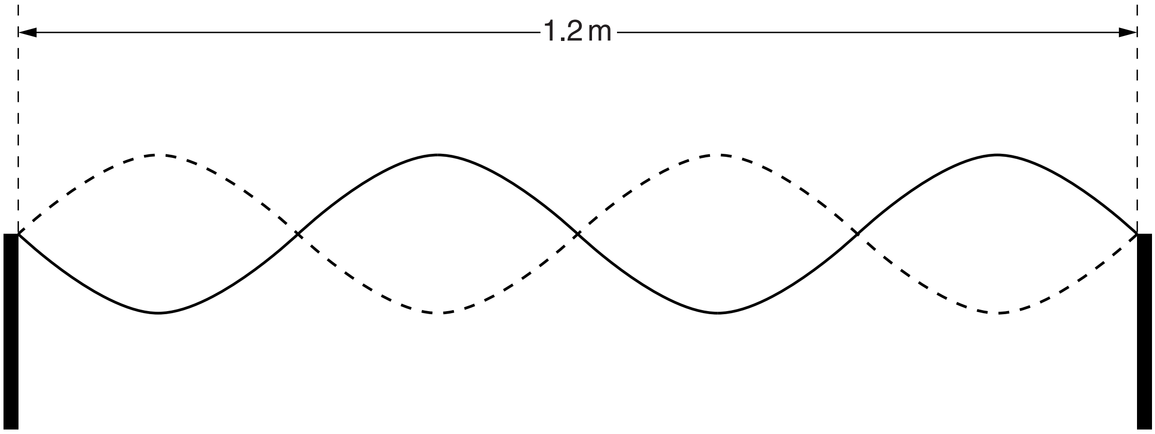


Fig. 4.1

(a) Write down the wavelength of the wave.

wavelength = ... m **[1]**

(b) Calculate the speed of the wave.

speed = ... $m\,s^{-1}$ **[1]**

5 Parallel wavefronts of wavelength λ and frequency *f* pass through a gap of width *d* and spread out by diffraction.

Which one of the following **must** cause the amount of spreading to **increase**?

Put a tick (✓) in the box next to the correct statement.

decreasing *d* and increasing λ ☐

increasing *d* and decreasing λ ☐

decreasing *d* and increasing *f* ☐

increasing *d* and decreasing *f* ☐

[1]

6 Fig. 6.1 shows two paths of light leaving a source, passing through two slits and reaching a point on a screen.

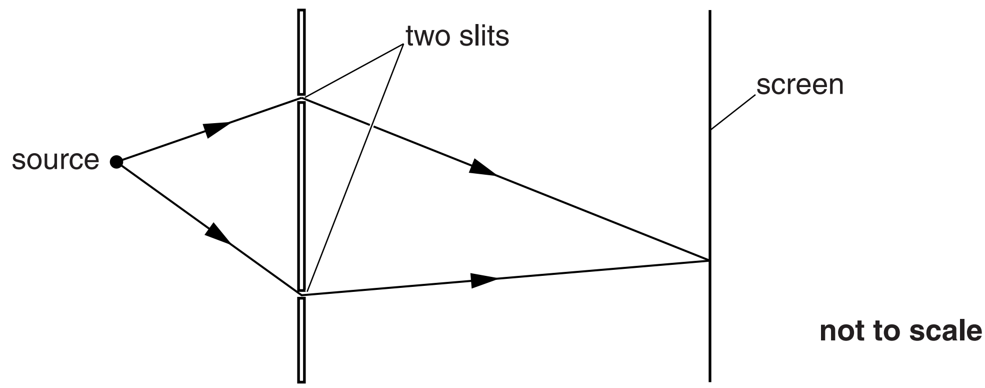


Fig. 6.1

Which of the following statements about photons arriving at a point on the screen are true?

Put a tick (✓) in the box next to **each** correct statement.

Visible light photons travel faster than infrared photons. ☐

The energy of a photon increases with the frequency of the radiation. ☐

The probability of a photon reaching the point can be found by considering the phasors for all photon paths. ☐

More than one photon must reach the point at once if there is to be destructive interference at that point. ☐

[2]

7 Two parallel clear lines are scratched on a darkened glass slide, 0.1 mm apart.
When a beam of light is shone through the slits, interference fringes are observed on a screen 1.5 m distant.
Measurement of these fringes is shown in Fig. 7.1.

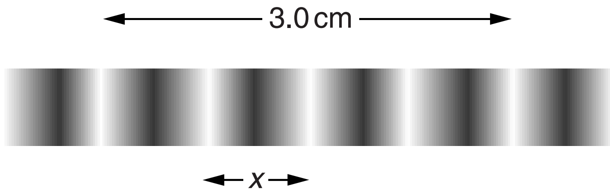
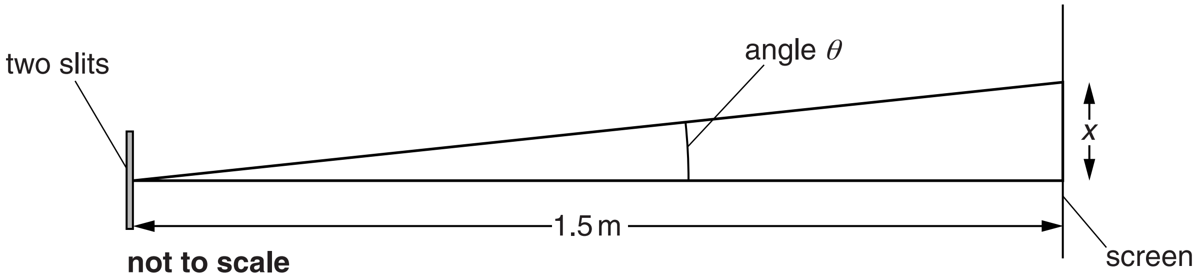


Fig. 7.1

(a) Calculate the fringe separation x in metres.

x = ... m **[1]**

(b) The first order diffraction angle θ is related to the fringe spacing x and distance to the screen as shown below.



Show that the angle θ is about 0.3°.

[2]

(c) Calculate the wavelength of light from the data given.

wavelength = ... m **[2]**

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Question 8 begins on page 8

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SECTION B

8 After a natural disaster, aeroplanes are often used to drop emergency supplies to people who cannot be reached by other means.
Fig. 8.1 shows the trajectory of a pack of supplies dropped in this way.

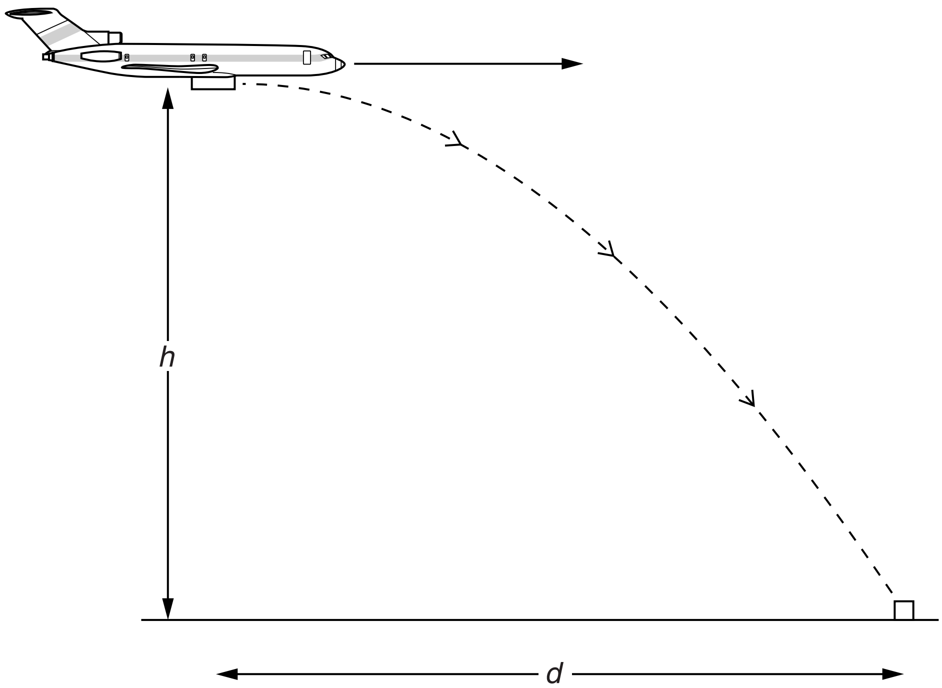


Fig. 8.1

(a) In this part of the question, you should ignore air resistance.

(i) Show that it would take a pack of supplies a time t of about 3 s to land, falling from a height h of 50 m.
$g = 9.8\,\text{m}\,\text{s}^{-2}$

[2]

(ii) Explain why the horizontal distance d travelled by the pack while it falls for a time t is given by

$$d = vt$$

where v is the horizontal speed of the plane at the time of release of the pack.

[2]

(iii) Calculate the value of *d* for a plane travelling at a speed of $120\,m\,s^{-1}$ at a height of 50 m.

d = ... m **[1]**

(b) For certain supplies, it is essential that they land at a much lower speed, so a parachute is used.

A parachute cannot be used for a pack dropped from heights below 200 m.

Suggest an item which would need to be dropped by parachute. Discuss why using a parachute and dropping the pack from a height above 200 m might prevent the pack reaching its intended destination.

In your answer you should consider different factors which may prevent the pack reaching its intended destination.

[4]

[Total: 9]

9 This question is about generating electricity using a wave power generator.
Fig. 9.1 shows a simple model of a wave power generator.

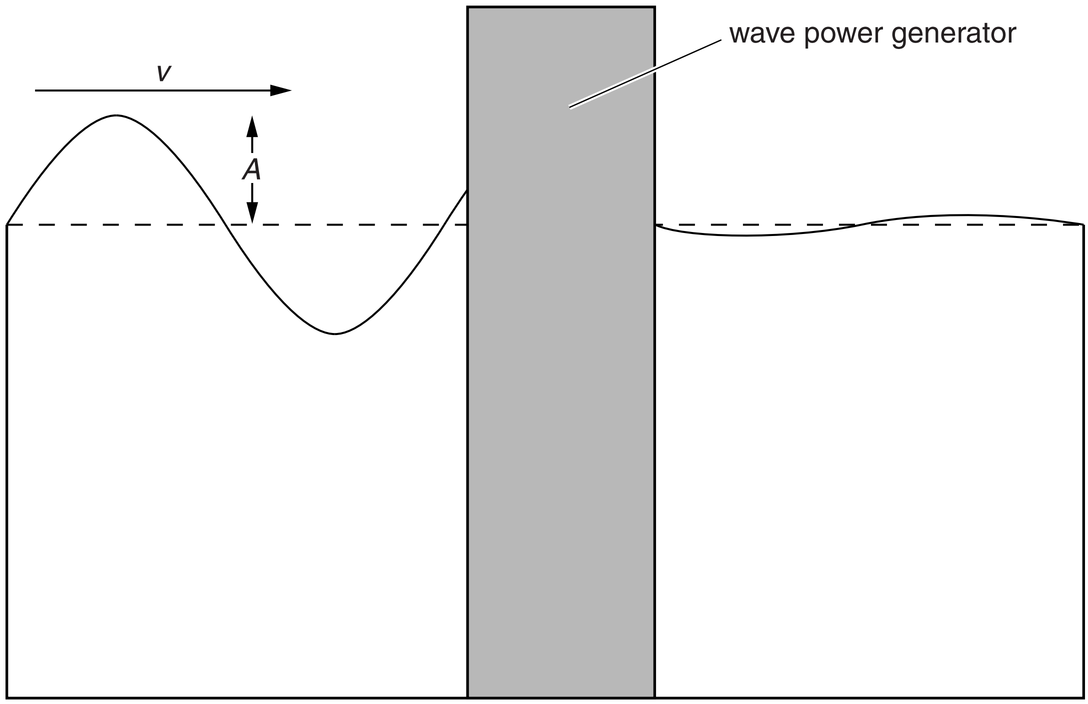


Fig. 9.1

Waves of amplitude *A* enter the generator and leave it with almost no amplitude at all.

(a) The waves move a float inside the generator, doing work so that energy is extracted from the wave.

(i) As the wave crest enters the generator, it pushes the float upwards and then pushes it back down to its mean position.
As the wave trough enters the generator, it pushes the float downwards and then pushes it back up to its mean position.
Assume that the mean force of each 'push' is 5000 N.
Calculate the work done by a wave of **amplitude** 3 m during one complete oscillation.

work done = ... J **[2]**

(ii) The wave has a speed of $4\,\mathrm{m\,s^{-1}}$ and a wavelength of 10 m.
Calculate the period of oscillation of the wave.

period = ... s **[2]**

(iii) Find the mean power delivered to the generator by the waves.

mean power = ... W **[2]**

(b) A typical modern gas-fired power station has an output of about 1 GW. A wave generator taking up 5 metres of coastline can generate up to 50 kW. Discuss the feasibility of combining wave generators to provide 1 GW.

In your discussion of the feasibility of the scheme you should justify your conclusions with appropriate calculations.

[4]

[Total: 10]

10 The wavelengths of light emitted by excited hydrogen gas can be measured using the arrangement shown in Fig. 10.1.

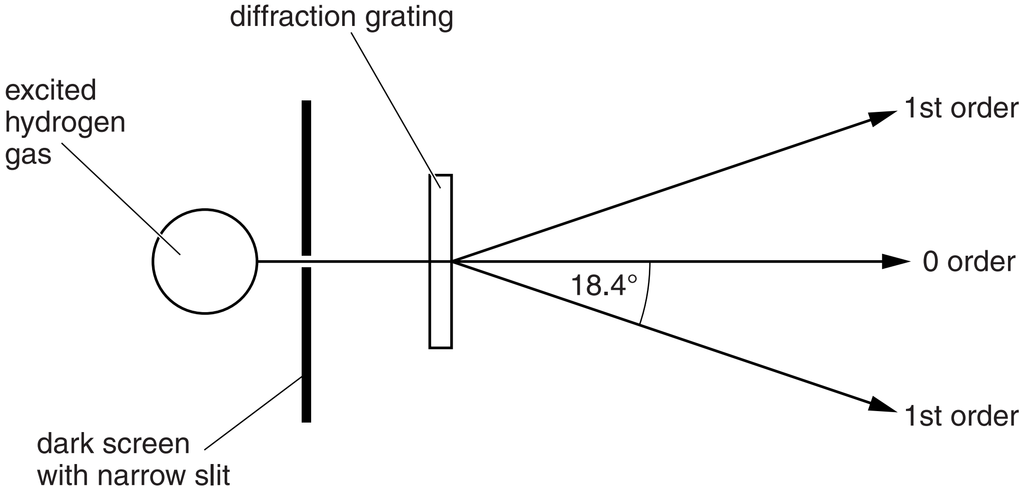


Fig. 10.1

(a) The diffraction grating used has 650 lines per mm.

(i) Show that the grating spacing is about 1.5×10^{-6} m.

[2]

(ii) Calculate the wavelength of the light diffracted at the angle shown in Fig. 10.1.

wavelength = ... m **[2]**

(b) Light emitted by excited hydrogen gas has certain wavelengths only.

Quantum theory explains this by assuming that the electron in the hydrogen atom can have only certain energies. These different energies form a 'ladder' of energy levels. Fig. 10.2 opposite shows the lowest four levels for the hydrogen atom.

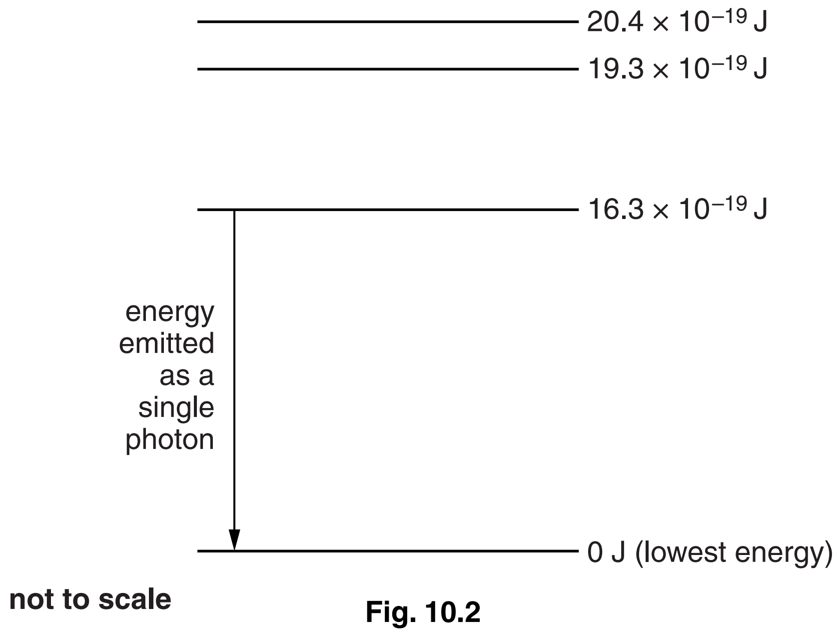


Fig. 10.2

When an electron 'falls' from one energy level to a lower one, the energy is emitted as a single photon.

(i) Show that the ultraviolet light emitted by the energy level change shown in Fig. 10.2 has a frequency of about 2.5×10^{15} Hz.
Planck constant, $h = 6.63 \times 10^{-34}$ J s

[2]

(ii) Visible light has wavelengths between 400 nm and 700 nm.
The lowest photon energy in this range is 2.84×10^{-19} J.
Calculate the highest energy of a photon of visible light.
speed of light, $c = 3.00 \times 10^{8}$ m s^{-1}

energy = ... J **[2]**

(iii) Draw lines on Fig. 10.2 above, using the information from **(b)(ii)**, to show energy level changes that would produce

1 a visible photon — label this V

2 an infrared photon — label this IR.

[2]

[Total: 10]

11 This question is about a helicopter.

(a) The helicopter has a mass of 9500 kg. Show that the upward force that the rotors must provide to keep the helicopter hovering at a constant height is about 90 kN.

$g = 9.8\ \text{m s}^{-2}$

[1]

(b) The helicopter is tilted as shown in Fig. 11.1 so that it can move horizontally.

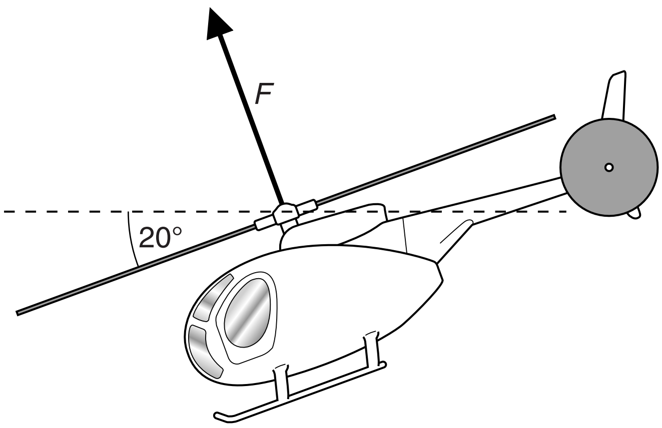


Fig. 11.1

(i) Draw a vector diagram, showing the horizontal and vertical components of the force *F* when the helicopter is tilted at an angle of 20°.
Label each component with its value in terms of *F*.

[3]

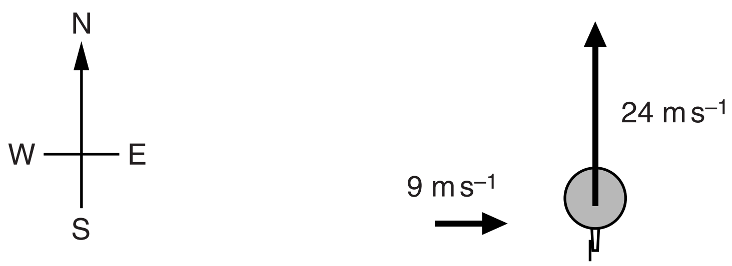
(ii) Use the vector diagram to show that the force *F* required to keep the helicopter at a constant height must now be nearly 100 kN.

[2]

(iii) Use the vector diagram to calculate the initial horizontal acceleration of the helicopter.

acceleration = ... $m\,s^{-2}$ **[2]**

(c) The helicopter can travel at a constant horizontal velocity of $24\,m\,s^{-1}$ in still air.
The helicopter is heading due north. There is a side wind blowing due east with a velocity of $9\,m\,s^{-1}$.



view from above

Calculate the resultant velocity of the helicopter relative to the ground.

magnitude of velocity = ... $m\,s^{-1}$

direction = ...
[3]

[Total: 11]

SECTION C

12 This question is about the article *Simple measurements of stress and strain.*

(a) (i) The resolution of a tape measure is estimated to be 0.5 mm.
Calculate the percentage uncertainty in using this tape measure to measure the length of a 5 m copper wire.

percentage uncertainty = ± .... % **[2]**

(ii) The extension of the wire when stretched is expected to be about 2 mm. The same tape measure is used to measure the extension. Explain why this gives a much greater percentage uncertainty when measuring the extension than when measuring the length.

[1]

(b) (i) A tensile force of 20 N, with an uncertainty of ± 0.2 N, was applied to the 5 m copper wire. The extension was measured using a device with a resolution of 0.1 mm. The experiment was repeated 8 times. The results are recorded in Table 12.1.

Extension / mm							
2.5	2.8	3.2	2.3	2.9	2.0	2.4	2.7

Table 12.1

Calculate the mean value and the spread for this set of data.

mean = ... mm

spread = ... mm
[3]

(ii) One measurement of the extension was found to be 1.8 mm. This was considered to be an outlier and was not included in the results. By considering the data in Table 12.1, explain whether this is justified.

[2]

(c) **(i)** Micrometers as shown in Fig. 12.2 have a main scale which measures to the nearest 0.5 mm and a fine scale which is divided into a further 50 divisions.

State the resolution for this micrometer.

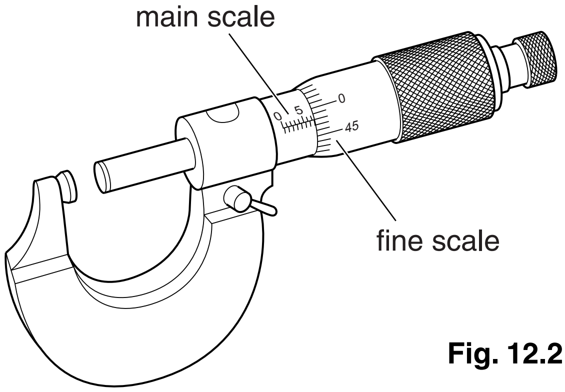


Fig. 12.2

resolution = ... mm **[1]**

(ii) The micrometer was used to measure the diameter of the 5 m copper wire in several different places along its length. Explain why this was done.

[2]

(iii) The average value obtained for the diameter is 0.61125 mm. State this value to an appropriate number of significant figures.

diameter = ... mm **[1]**

(d) The measured values for stress and strain can be used to calculate the Young modulus *E* for the 5 m copper wire used. Using the data above gives a value

$$E = (1.3 \pm 0.4) \times 10^{11}\,\text{Pa}.$$

Suggest **one** way in which the experiment could be modified to give a value of *E* with a much smaller uncertainty. Ensure that you explain the effect of your suggestion on each experimental variable.

[3]

[Total: 15]

13 This question is about the article *The performance of wind turbines.*

(a) Explain why it is difficult to make a valid comparison of the performance of different wind turbines.

[2]

(b) Table 13.1 compares the power output of three wind turbines **A**, **B** and **C** across a range of wind speeds from 0 to 10 $m\,s^{-1}$.

	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 13.1

(i) State, with a reason, which turbine you would select for a location with wind speeds generally 4 $m\,s^{-1}$ or lower.

[1]

(ii) State, with a reason, which turbine you would select for a location that regularly experiences winds in excess of $10\,\mathrm{m\,s^{-1}}$. State any assumption that you might make in your use of the data.

[2]

(c) It suggested that the output power of any turbine is proportional to the cube of the wind speed.
The data for turbine **A** is given in Table 13.2.

Wind speed v/m s^{-1}	**v^3/m^3 s^{-3}**	**Power output/kW**
0	0	0
1	1	0
2	8	0
3	27	0
4	64	0.08
5	125	0.50
6	216	0.97
7	343	1.48
8	512	2.20
9		3.06
10		4.22

Table 13.2

(i) Complete the table.
Plot the two additional points on the graph of Fig. 13.3 on page 20 and draw a line of best fit.

[3]

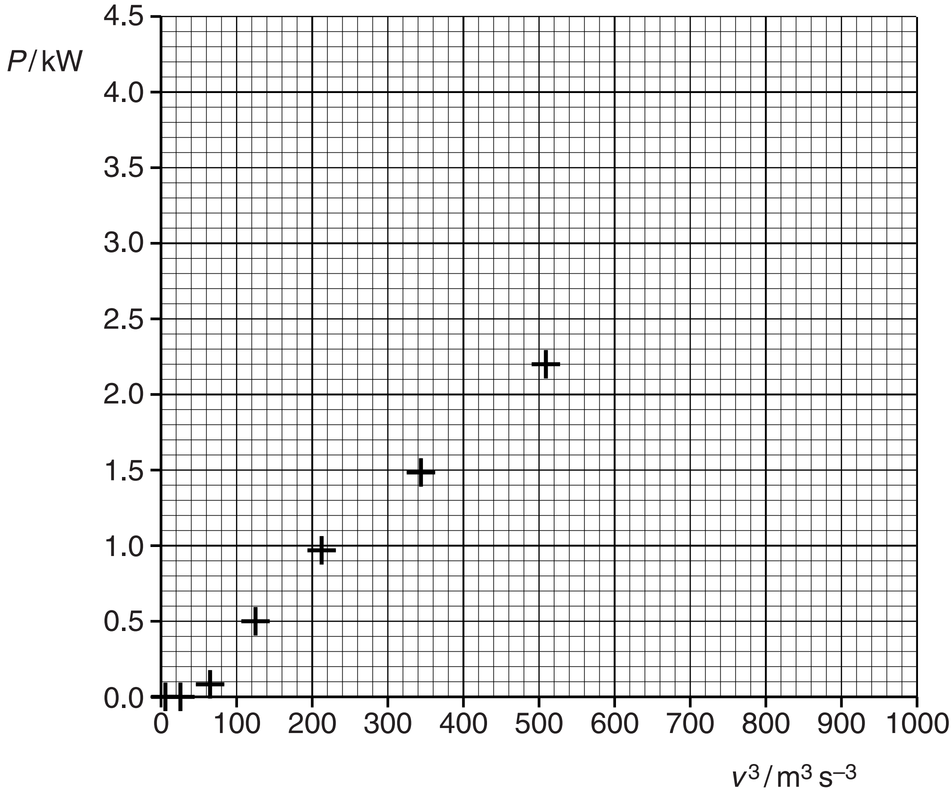


Fig. 13.3

(ii) Use the graph to make conclusions about the relationship between the power output of the turbine and the wind speed.

[2]

(d) It is proposed that the relationship between the area A swept out and the power output P of the wind turbine is given by the equation

$$P = kA$$

where k is a constant.
Use data from Table 13.4 to test the relationship.

Rotor diameter / m	**Power output / kW**
1	0.4
2	1.6
4	6.3

Table 13.4

Proposed test

Working

Conclusion

[3]

[Total: 13]

14 This question is about the article *Calculating longitude.*

(a) (i) Show that the physical distance equivalent to 1 degree of longitude is approximately 100 km **at the Equator**.

radius of the Earth = 6380 km

[2]

(ii) Experienced navigators could typically make angle measurements that gave an uncertainty of one quarter of a degree in longitude. Estimate the uncertainty in the distance equivalent to one degree of longitude at the Equator.

uncertainty = ± .... km **[1]**

(b) (i) Show that 15° of longitude corresponds to a one hour difference in local time.

[1]

(ii) When it is noon (12:00) in New York, the Greenwich Mean Time is 16:56.
Calculate the longitude of New York.

longitude = ... ° W **[2]**

(iii) New York is not on the Equator, but is 41° N. Explain why it is not possible to use the distance calculated in **(a)(i)** to find the distance between Greenwich and New York.

[2]

(c) Mechanical clocks could not be used on ships to give accurate values of Greenwich Mean Time until after 1800, although accurate pendulum clocks were available.

(i) Explain why pendulum clocks could not be used on ships.

[1]

(ii) When chronometers (accurate mechanical clocks) were eventually developed, it was usual for ships to carry several of them on long journeys.
Suggest reasons for taking three or more chronometers.

[2]

[Total: 11]

END OF QUESTION PAPER

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Friday 18 January 2013 – Morning

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes / Experimentation and Data Handling

INSERT

Duration: 2 hours

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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

- Do not send this Insert for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Turn over

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.

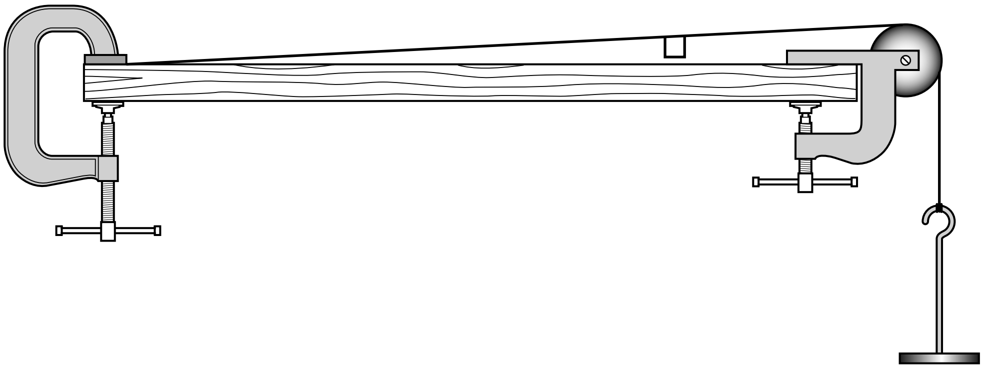

Fig. 1.1

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.

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.

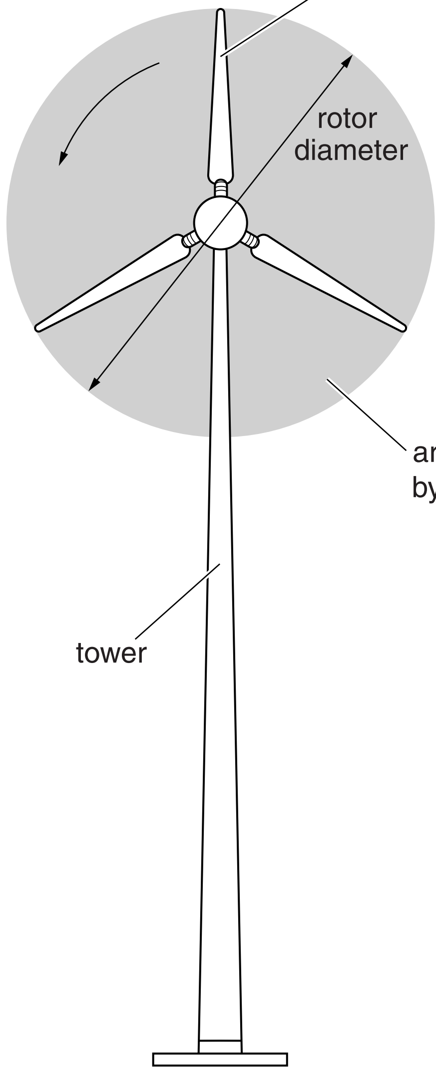

Fig. 2.2

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.

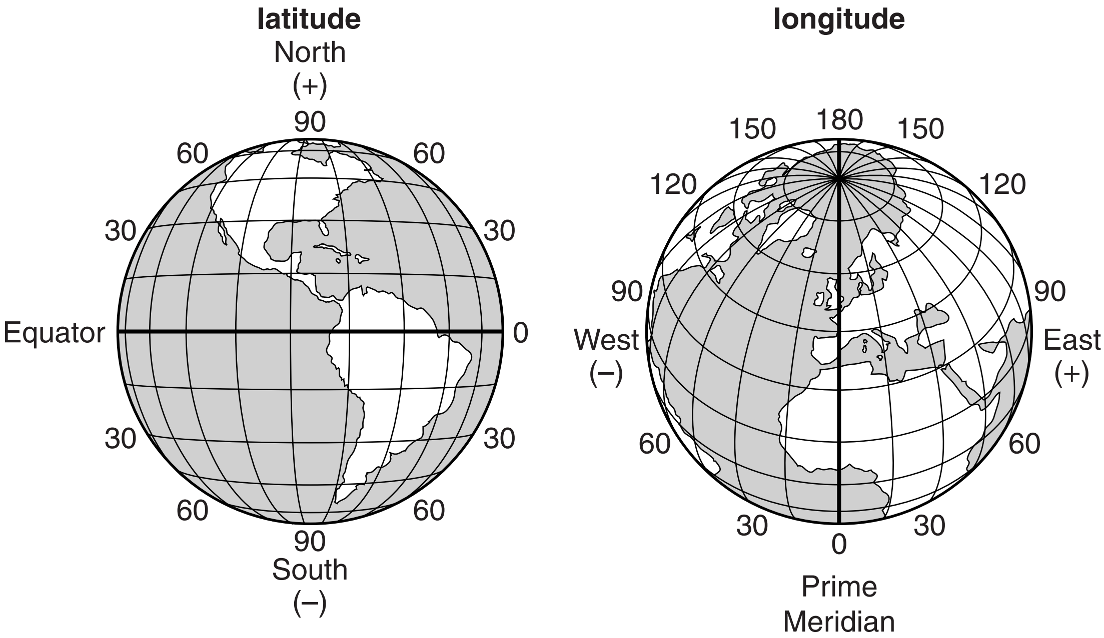

Fig. 3.1

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.

END OF ARTICLE