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OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS) G492

Unit G492: Understanding Processes/
Experimentation and Data Handling

Candidates answer on the Question Paper

OCR Supplied Materials:
- Insert (Advance Notice Article for this question paper) (inserted)
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)

Wednesday 13 January 2010
Morning

Duration: 2 hours

OCE/10152

G492

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

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 **28** pages. Any blank pages are indicated.
- The questions in Section C are based on the material in the Insert.

Answer **all** the questions.

Section A

1 The following five expressions are combinations of quantities used in AS physics. The variables shown by letters have their usual meanings.

hf $\quad$ Fv $\quad$ $\frac{1}{2}mv^2$ $\quad$ $d\sin\theta$ $\quad$ $\frac{1}{2}at^2$

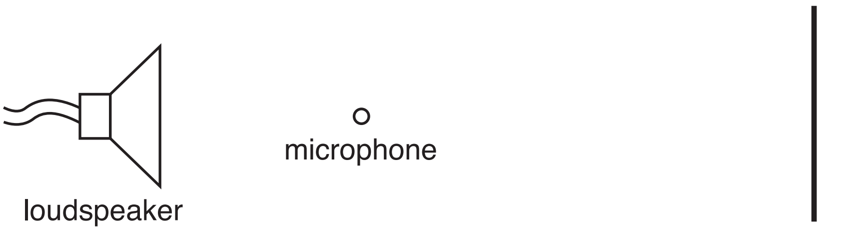
(a) Which **two** expressions are used to calculate an energy?

.... **[1]**

(b) Which **two** expressions are used to calculate a distance?

.... **[1]**

2 A loudspeaker is placed in front of a reflector, and a microphone is placed at a point where there is a **maximum** amplitude.



The reflector is moved a distance x to the left. The amplitude of the signal detected is now a **minimum**.

Which of the following is the value of x in terms of the wavelength λ of the sound?

$\frac{\lambda}{4}$ $\quad$ $\frac{\lambda}{2}$ $\quad$ λ $\quad$ 2λ

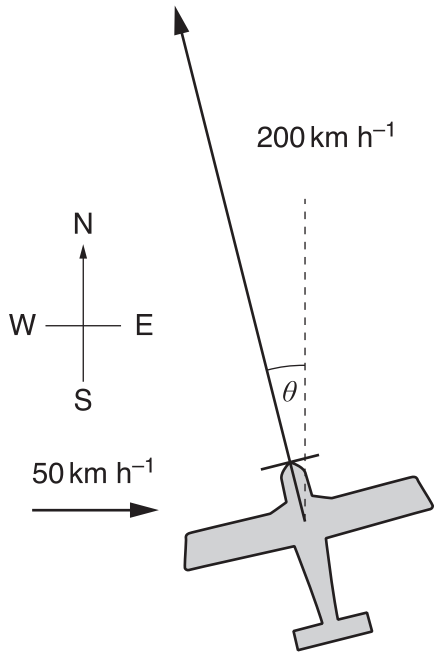
x = ... **[1]**

3 A small aircraft flies at a velocity of 200 km h^{-1} relative to the ground.

There is a wind blowing at 50 km h^{-1} from the west.

The pilot wishes to reach a destination due north of the starting point.
Find the resultant speed v of the aircraft, and the angle θ , west of north, which it must take.

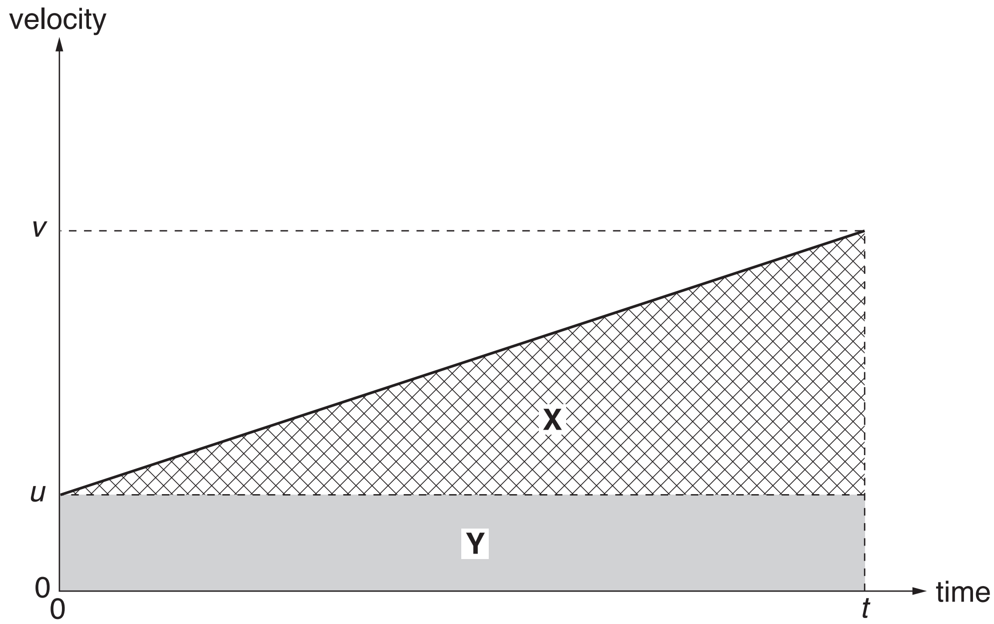
Show your working clearly.
You may wish to draw a vector diagram.



v = ... km h^{-1}

θ = ...°W of N **[3]**

4 The velocity-time graph below is for an object undergoing constant acceleration *a*.



Which of the following statements about the areas **X** and **Y** are correct?

Put ticks (✓) in the **two** correct boxes.

X = ut ☐

X = $\frac{1}{2}ut$ ☐

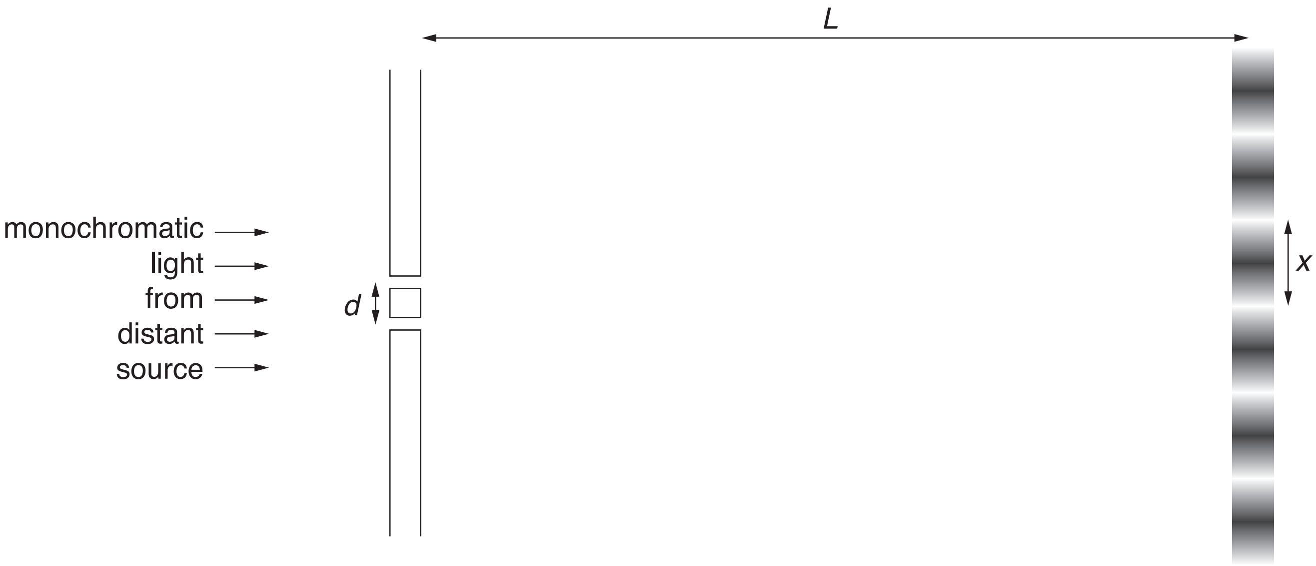
X = $\frac{1}{2}at^2$ ☐

Y = ut ☐

Y = $\frac{1}{2}vt$ ☐

Y = $\frac{1}{2}at^2$ ☐ **[2]**

5 Monochromatic light (light of one wavelength only) from a distant source falls upon two narrow slits separated by a distance *d*.
A pattern of bright and dark bands, called fringes, each separated by a distance *x*, is seen on a screen a distance *L* away.



When light of wavelength 590 nm is used and the screen is at a distance L = 1.2 m from the slits, the separation of the fringes x = 3.5 mm.

Calculate the slit separation *d*.

d = ... m **[3]**

6 A light-emitting diode (LED) emits photons of energy 3.5×10^{-19} J.

(a) Calculate the frequency of this radiation.

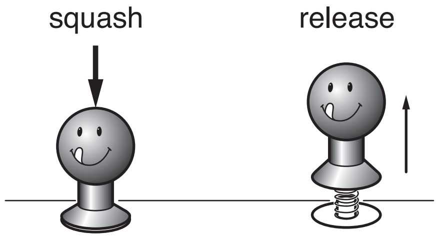
the Planck constant $h = 6.6 \times 10^{-34}$ J s

frequency = ... Hz **[2]**

(b) Calculate the output power of the LED when it emits 1.2×10^{17} photons each second.

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

7 A popular toy has a plastic 'head' and a circular base fixed at each end of a spring. When the spring is compressed and then released, the toy jumps into the air.



(a) The mass of the toy is 6.0×10^{-3} kg.
Calculate the minimum energy that must be stored in the spring for the toy to jump 0.50 m into the air.

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

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

(b) When the toy is squashed, the spring is compressed from a length of 30 mm to a length of 9 mm.
The **average** force applied to compress the spring is 3 N.
Calculate the work done in compressing the spring.

work done = ... J **[3]**

[Section A Total: 20]

Section B

8 In the 2008 Beijing Olympics, the Jamaican sprinter Usain Bolt won both the 100 metres and 200 metres races in record times.

Fig. 8.1 is the velocity-time graph for Usain in one of these two races.

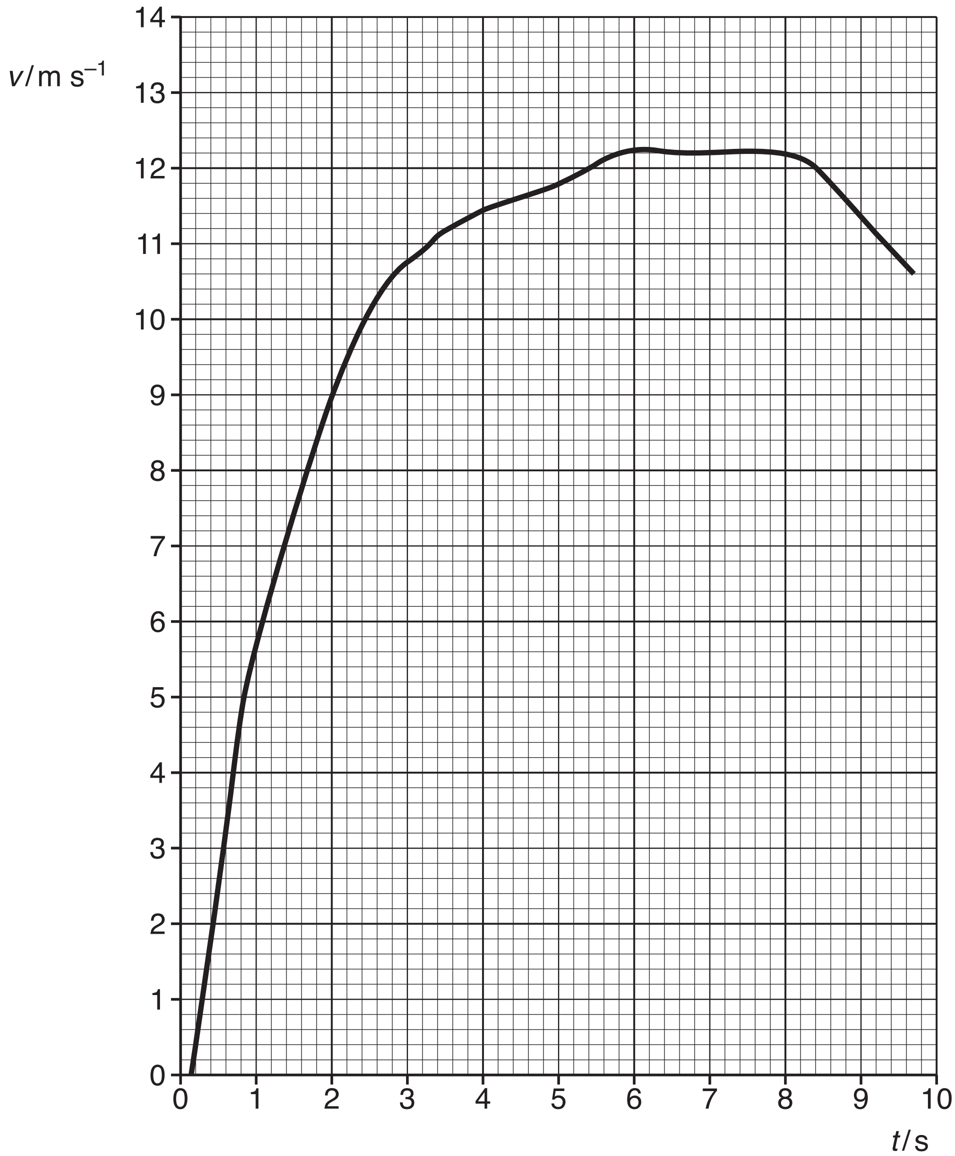


Fig. 8.1

(a) **(i)** The starting gun was fired at the time $t = 0$.
Use the graph to estimate Usain's reaction time to the starting gun.

reaction time = ... s **[1]**

(ii) Use data from both axes of the graph to show that this was the 100 m race.

[2]

(b) **(i)** Use the graph to estimate the horizontal force with which Usain pushed back on the starting block as he began to run.

mass of Usain Bolt = 88 kg

force = ... N **[3]**

(ii) Explain why this answer cannot be more than an estimate.

[1]

(c) Commentators describing this race noted that Usain seemed to relax once he knew he could not be passed, and that this happened about 20 metres from the end.
Use data from the graph to check this statement.

You should ensure that you use data from the graph and explain your findings clearly.

[3]

[Total: 10]

9 This question is about the mercury spectrum and the photoelectric effect.

(a) The plot of the relative intensity against wavelength of the light emitted by a mercury lamp is shown in Fig. 9.1. This spectrum consists of six sharp lines, labelled **A** to **F**, each one corresponding to a single wavelength.

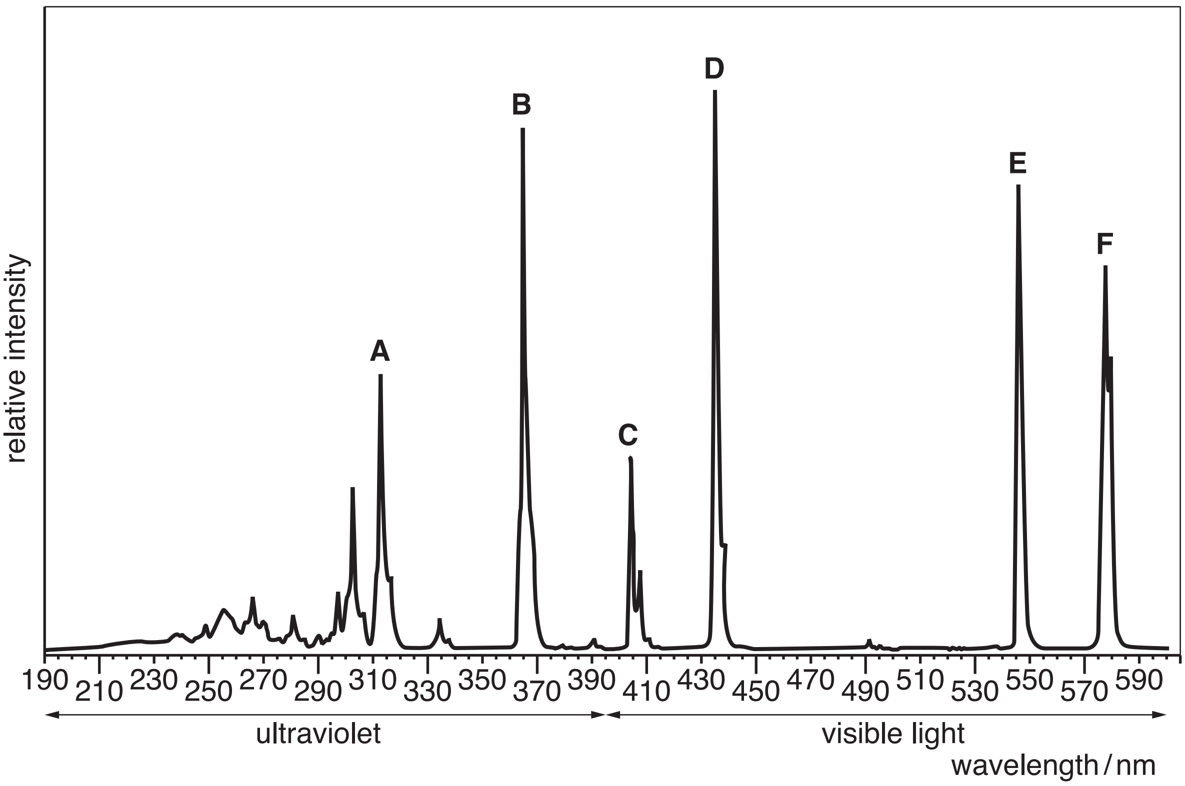


Fig. 9.1

Answer each of the following questions using one or more of the letters **A**, **B**, **C**, **D**, **E** or **F**.

(i) Which **one** of the wavelengths has the lowest photon energy?

.... **[1]**

(ii) Which of the wavelengths are invisible to the human eye?

.... **[1]**

(b) Light from the mercury lamp is separated into beams at the six different wavelengths using a diffraction grating as shown in Fig. 9.2.

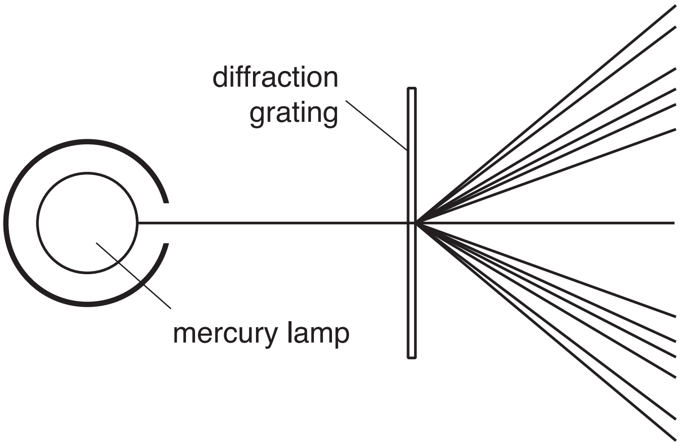


Fig. 9.2

On Fig. 9.2, label the beams of wavelengths **A** and **F**. **[2]**

(c) Light of different wavelengths from the mercury lamp is shone onto a clean calcium surface. Photons at some of the wavelengths cause electrons to be emitted from the calcium, as shown in the table below.

wavelength / nm	maximum kinetic energy of electrons emitted / 10^{-19} J
310	1.8
360	0.82
405	0.19
435 or longer	none emitted

(i) Show that the energy of a photon of light of wavelength 360 nm is about 5×10^{-19} J.

speed of light $c = 3.0 \times 10^{8}\,\text{m s}^{-1}$

the Planck constant $h = 6.6 \times 10^{-34}\,\text{J s}$

[3]

(ii) Show that an electron must absorb an energy of at least 4.7×10^{-19} J to escape from the calcium surface.

[2]

[Total: 9]

10 This question is about standing waves producing musical notes in an Australian instrument called the didgeridoo (Fig. 10.1).

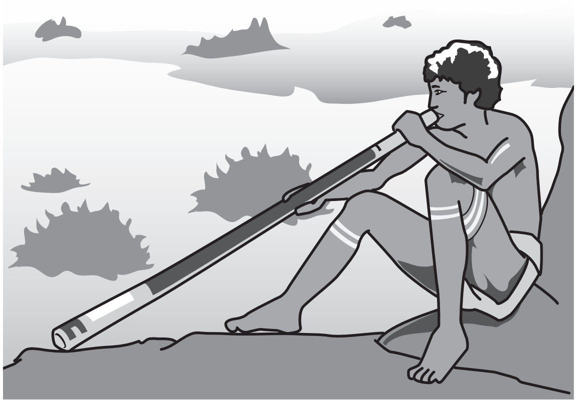


Fig. 10.1

(a) By blowing in one end of the hollow wooden tube, different notes can be produced.
Each note produced has a **node** of no displacement at the end that is blown, and an **antinode** of maximum displacement at the other end.

(i) Explain how a standing wave with nodes and antinodes is formed in the tube.

In your answer, you should use appropriate technical terms, spelled correctly.

[3]

(ii) A didgeridoo is 1.6 m long.
Calculate the frequency of the lowest note produced by this didgeridoo.

speed of sound in air = 340 m s^{-1}

frequency = ... Hz **[3]**

(iii) Another strong note produced by the didgeridoo has three times the frequency of the lowest note.
Mark the position of the nodes and antinodes in the didgeridoo in Fig. 10.2 that produce this higher frequency. Label each node **N** and each antinode **A**.

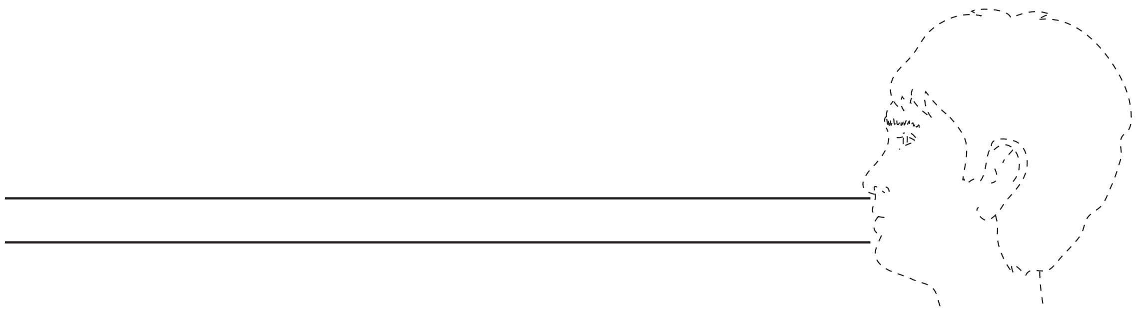


Fig. 10.2

[3]

(b) The speed of sound in the tube is not constant, but changes with the temperature of the air in the tube. As the temperature rises, the speed rises also, and the frequency of the note rises with it.
After some use, the temperature of the didgeridoo can increase to about 35 °C.
The following data give the frequency of the lowest note of a didgeridoo at three different temperatures.

temperature / °C	frequency / Hz
15	74.0
25	75.3
35	76.6

Suggest and carry out a test on these data to see whether the frequency is directly proportional to the temperature in °C.

suggested test	test carried out
conclusion	

[3]
[Total: 12]

11 This question is about a computational model for the path of a projectile thrown horizontally at a speed of $5\,\text{m}\,\text{s}^{-1}$.
In this model, equal time intervals of 0.2 seconds are used.

(a) Explain why the horizontal displacement Δx during each time interval is constant at 1.0 m.

[2]

(b) The computer program for the model produces the graph of Fig. 11.1.

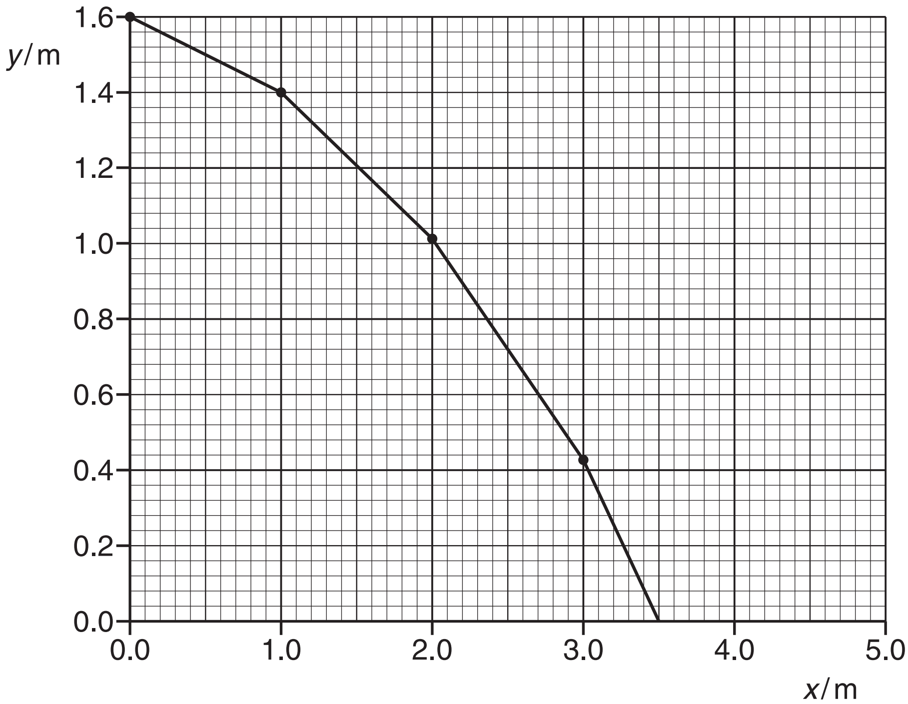


Fig. 11.1

(i) The model makes the assumption that the vertical component of velocity does not change during each time interval.
Explain clearly how the graph shows this.

[2]

(ii) State how the graph shows that the projectile should hit the ground at about 0.7 s after it is thrown.

[2]

(iii) Do a calculation to show that the time taken for a real object to fall vertically from rest through a distance of 1.6 m is significantly less than 0.7 s.

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

[2]

(iv) The answers to **(ii)** and **(iii)** above show that the computational model produces vertical components of velocity which are too small.
Explain why this is the case.

[1]

(c) Suggest and explain a change which could be made to the model to produce a graph which more accurately matches the curve produced by a real projectile.

[2]

[Total: 11]

[Section B Total: 42]

Section C

The questions in this section are based on the material in the insert.

12 This question is about the article *Calibration of instruments*.

The calibration graphs obtained from the thermistor circuit (Fig. 1 in the insert) for three different fixed resistors are shown in Fig. 12.1 (Fig. 2 in the insert).

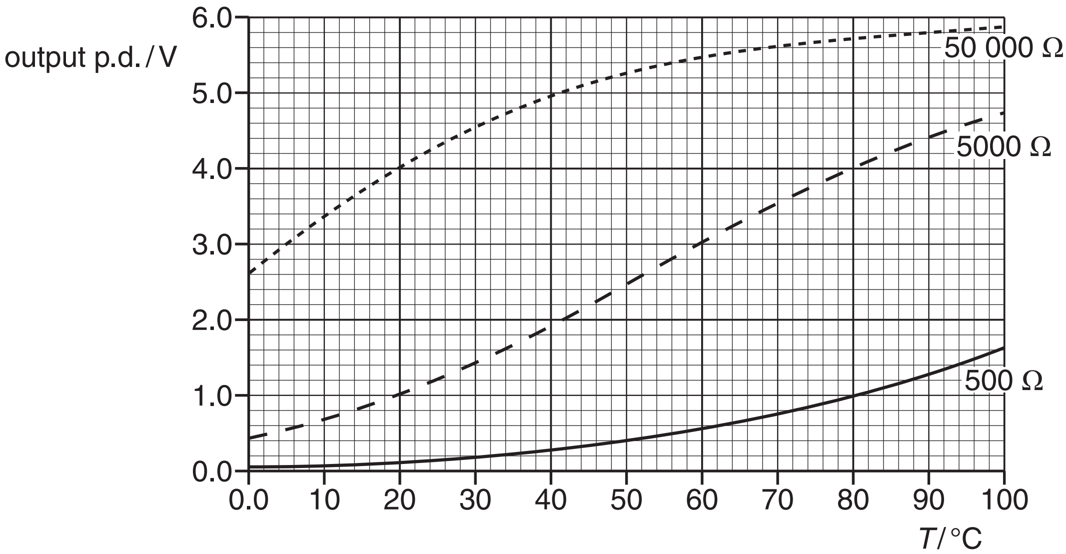


Fig. 12.1

(a) Use the graphs to answer the following questions.

(i) Which of the three values of the fixed resistor R gives the circuit the most linear response over the range 0 – 100 °C?

.... Ω **[1]**

(ii) Which of the three values of the fixed resistor R gives the circuit the greatest range of output values?

.... Ω **[1]**

(iii) Which of the three values of the fixed resistor R gives the most sensitive circuit for switching on a refrigerator when its temperature rises above 4 °C?

.... Ω **[1]**

(b) Calculate the **average** sensitivity of the circuit in the temperature range 0 – 20 °C when the fixed resistor R is 50 000 Ω.
Show your working clearly on the graph of Fig. 12.1 and in this space.
Write down also the unit in which this sensitivity is measured.

sensitivity = ... unit ....**[4]**

(c) The digital voltmeter used in the circuit (Fig. 1 in the insert) has a voltage resolution of 0.01 V. Calculate the temperature resolution of the circuit over the range 50 – 60 °C when the fixed resistor R is 5000 Ω.

temperature resolution = ... °C **[3]**

[Total: 10]

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13 This question is about the article *Spectacles for the Third World*.

(a) The table below gives the measurements obtained by the engineer.

u/m	v/m
0.10	0.17
0.11	0.21
0.12	0.24
0.13	0.29
0.14	0.36
0.15	0.42

(i) Use the data for $u = 0.11$ m to show that the power of the lens is about –4 D.

$$P = \frac{1}{v} - \frac{1}{u}$$

[1]

(ii) Explain why the data in the table above suggest that the uncertainty of each measurement is likely to be ± 0.005 m.

[1]

(iii) By considering the maximum and minimum possible values of u and v, estimate the uncertainty in the value of P obtained when $u = 0.11$ m.

uncertainty = ± ....D **[4]**

(b) The table gives the results of all the engineer's measurements. She decides to plot a graph of $\frac{1}{v}$ against $\frac{1}{u}$ to determine the best value of P, the power of the lens. Note that u is **positive** in this analysis, as the object is to the right of the lens.

u/ m	v/ m	$\frac{1}{u}$/D	$\frac{1}{v}$/D
0.10	0.17	10	5.9
0.11	0.21		
0.12	0.24		
0.13	0.29		
0.14	0.36	7.1	2.8
0.15	0.42	6.7	2.4

(i) Complete the columns for $\frac{1}{u}$ and $\frac{1}{v}$. **[2]**

(ii) Plot the results on the axes of Fig. 13.1. Three points have been plotted for you.

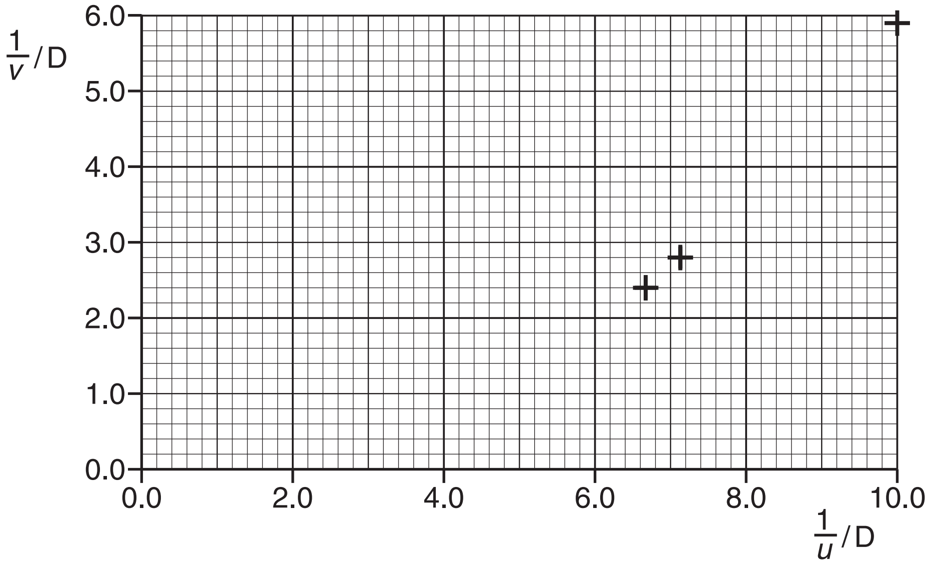

Fig. 13.1

[2]

(iii) Draw the best straight line through the points and use it to determine a value for the power of the lens.

power = ...D **[2]**

[Total: 12]

14 This question is about the article *Performance of commercial jet aircraft*.

(a) Use the data on the Airbus A340-600 below to answer the following questions.

type	cruising speed km/h	fuel consumption litre/h	fuel capacity /litre	range/km
Airbus A340-600	902	9800	195 600	13 900

(i) Show that the plane takes about 15 hours to travel the range at its cruising speed.

[1]

(ii) Show that the fuel consumed in travelling the range at cruising speed is less than 80% of the maximum fuel carried.

[2]

(iii) Suggest and explain one reason why the aircraft carries more fuel than that needed to travel its range at its cruising speed.

[2]

(b) Use the data on the MD-11 below to answer the following questions.

type	number of engines	maximum thrust per engine / N	maximum take-off mass / kg	takeoff distance / m
MD-11	3	270 000	273 900	3100

(i) Show that the initial acceleration of the MD-11, with maximum thrust and maximum take-off mass, is approximately $3\,\mathrm{m\,s^{-2}}$.

[2]

(ii) Use your answer to **(b)(i)** to calculate the distance required for the MD-11 to reach a take-off speed of $81\,\mathrm{m\,s^{-1}}$.

[2]

(iii) The distance calculated in **(b)(ii)** is substantially less than the quoted take-off distance of 3100 m.
Suggest and explain a reason for this.

[2]

(c) In level flight, the lift required is directly proportional to the **mass** of the aircraft.
Explain why.

[2]

(d) The graph of Fig. 14.1 shows the relationship between maximum take-off mass M and wing area A for all six aircraft in the table.

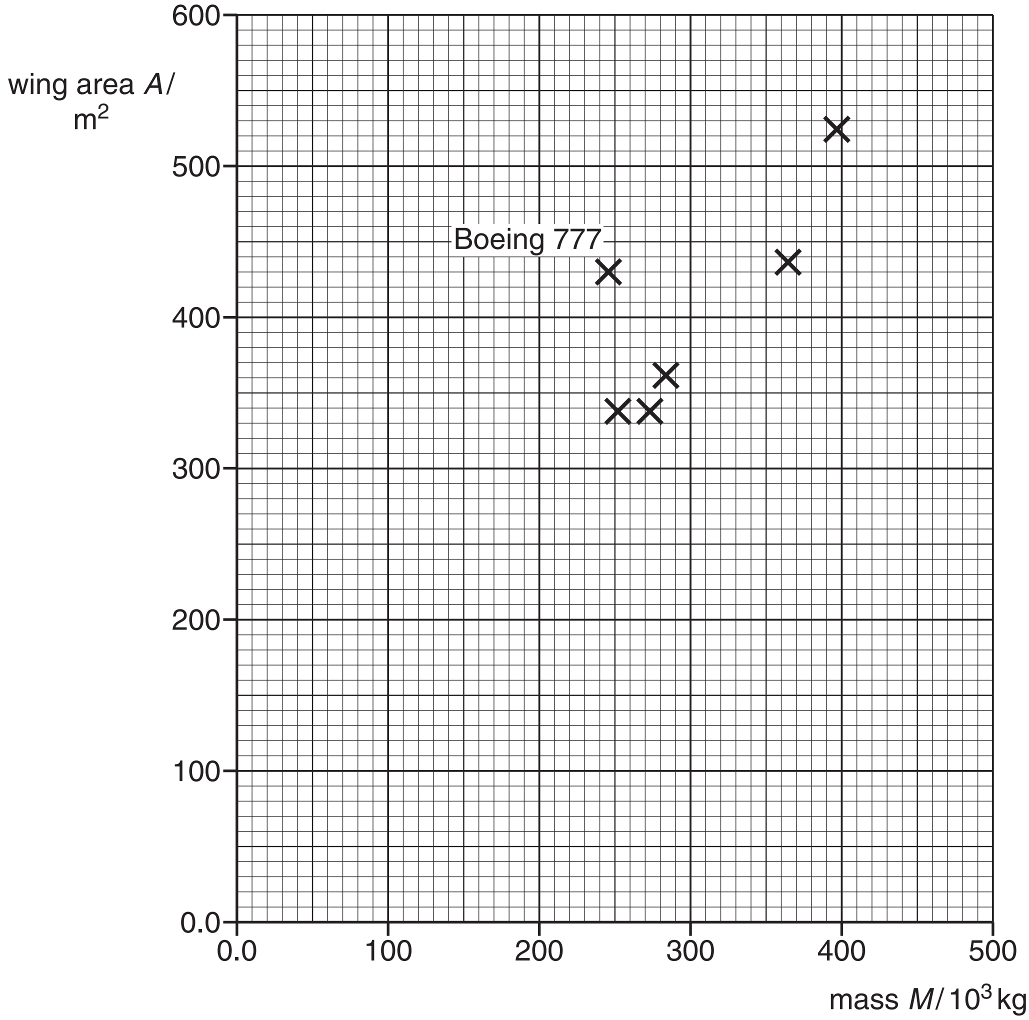

Fig. 14.1

Draw a straight line of best fit on Fig. 14.1.
What does the graph suggest about the design of these six aircraft?

[3]
[Total: 16]
[Section C Total: 38]

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ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS) G492

Unit G492: Understanding Processes /
Experimentation and Data Handling

INSERT

Wednesday 13 January 2010
Morning

Duration: 2 hours

OCE/12987

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.

1 Calibration of instruments

Sensor circuits usually need calibration before they can be used to make measurements. This involves measuring the output for different values of the input variable.
Measurements using the thermistor circuit Fig. 1 as a temperature sensor give the graphs shown in Fig. 2, showing the three calibration graphs obtained when the fixed resistor has the values 500 Ω, 5000 Ω and 50 000 Ω respectively.

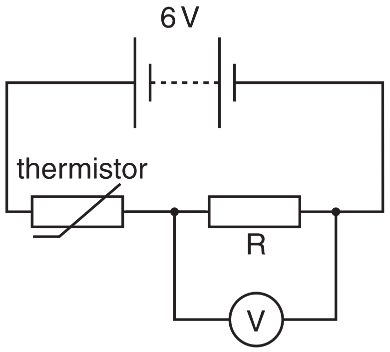

Fig. 1

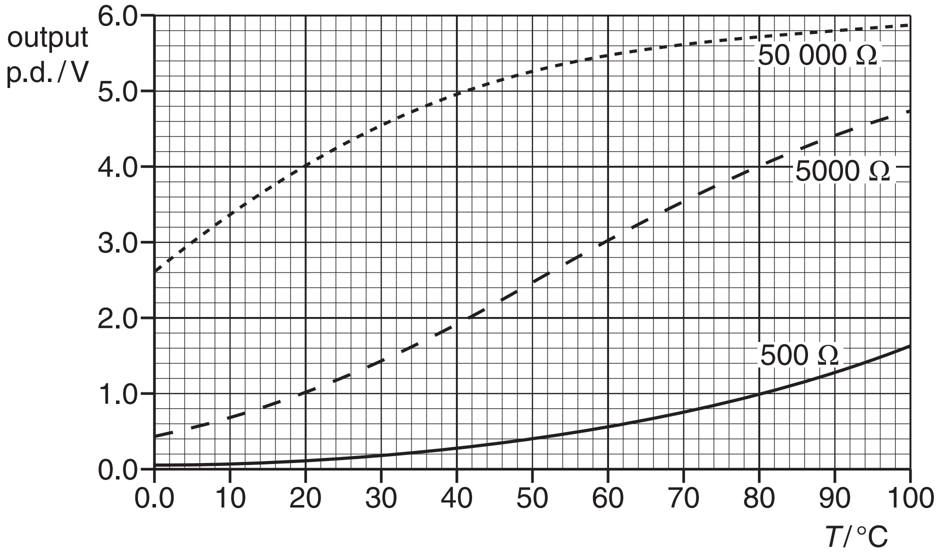

Fig. 2

The three calibration graphs show that using different values of fixed resistor changes the **sensitivity** of the circuit at different points of the temperature range, and affects the **linearity** of the relationship between input and output. The **range** of output values obtained is also different in each case, which affects the **resolution** of the circuit.

2 Spectacles for the Third World

Many charities collect unwanted spectacle lenses for reuse in the Third World. The power of these lenses varies from +5D (converging) to -5D (diverging), with the majority being in the latter category. There is a need for a quick and easy-to-use method of measuring the power of these lenses when they arrive at their destination, using appropriate technology and expertise.

Measurement of the power of a converging lens is fairly straightforward. All you need is a beam of parallel light, a piece of stiff white card and a ruler, as shown in Fig. 3.

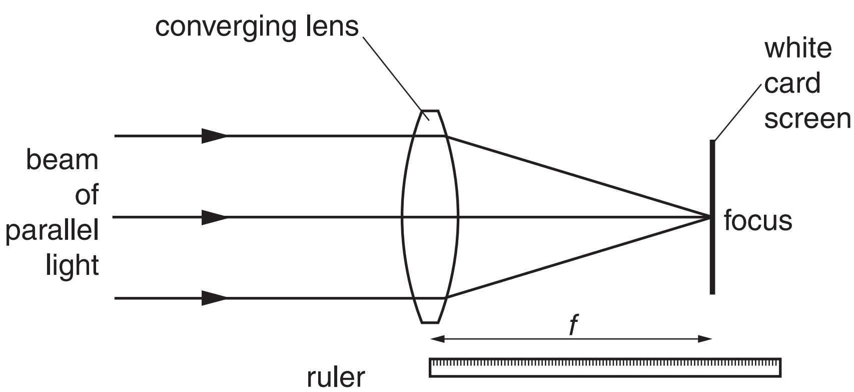

Fig. 3

This method does not work for a diverging lens. This is because the light which leaves the lens appears to come from a point behind it, where you cannot put a screen to find the focus, as shown in Fig. 4.

The way that a diverging lens *can* be made to focus light to a point on a screen is to use a converging lens to arrange for the incoming light beam to be already aiming to a focus, as shown in Fig. 5.

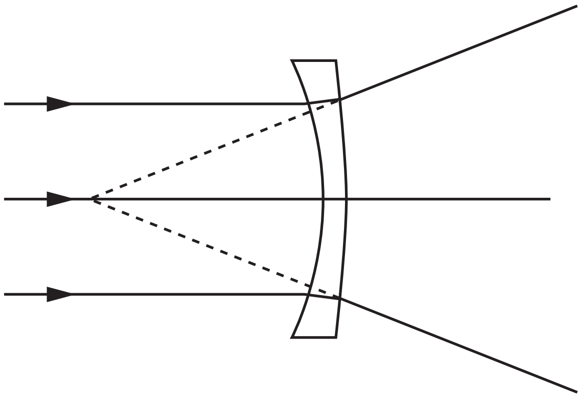

Fig. 4

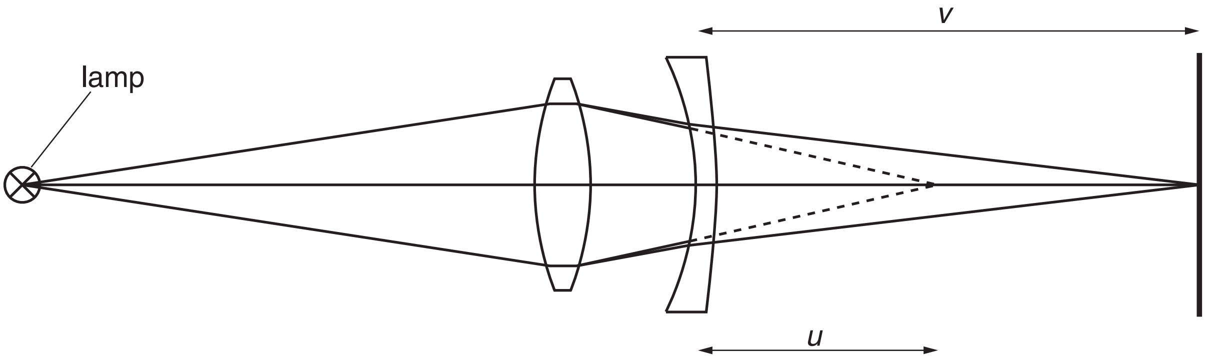

Fig. 5

A charity appoints an engineer to design a simple method for use in the Third World to measure the power of diverging spectacle lenses. She uses the arrangement shown in Fig. 5 and follows this procedure:

- With both lenses in place, measure the distance from the diverging lens to the position of the screen where the light is focused. This is the image distance, *v*.
- Remove the diverging lens, and move the screen until the light is focused by the converging lens alone. The distance from where the diverging lens was placed to the new screen position is the object distance, *u*.

The power *P* of the diverging lens is calculated from the formula $P = \frac{1}{v} - \frac{1}{u}$, where both the image distance *v* and the object distance *u* are **positive** because they are to the right of the lens.

The table gives a set of measurements obtained by this method. Different pairs of values of *u* and *v* are obtained by changing the distance from the lamp to the converging lens.

u/cm	10	11	12	13	14	15
v/cm	17	21	24	29	36	42

3 Performance of commercial jet aircraft

Although much criticised for their carbon footprint, modern jet aircraft have been developed to carry the largest load they can, at the greatest speed possible, for the smallest amount of fuel. This is basic economic good sense. However, some of these factors do compete with each other: the fastest commercial jet aircraft, Concorde, proved uneconomic to run, as it could not carry enough passengers to make its journeys profitable. It was taken out of service in 2003.

Weight and range

More recent jet aircraft are designed to carry many more passengers and their luggage than Concorde could. They also need to travel a quarter of the way around the world without refuelling. This means that they need to carry a lot of fuel, which can be over a third of the total weight of the plane! The planes themselves are necessarily larger, too, which further increases the weight to be carried.

Lift

In level flight, lift is produced by pressure differences produced by airflow across the wings, with lift depending on the speed and on the surface area of the wings. Cruising speeds of many jet aircraft are all rather similar, being just less than the speed of sound, so differences in lift are likely to depend mainly on the surface area and shape of the wings.

Take-off

Aircraft use fuel very rapidly at take-off, when the engines have to deliver maximum thrust. The aircraft must accelerate fast enough to reach the speed needed to take off, usually about 240 – 290 $km\,h^{-1}$ (150 – 180 miles h^{-1}) in a distance well within the length of the runways available. Because take-off speeds and runway lengths are all rather similar, the acceleration of most jet aircraft down the runway is similar, whatever their mass and total engine thrust.
After take-off, jet aircraft are required to climb steeply to avoid excessive noise nuisance. If the angles of climb are similar, this also requires maximum thrust to be related to total aircraft take-off weight.

Data on six aircraft are given in the table of Fig. 6 opposite.

type	number of engines	maximum thrust per engine / kN	maximum take-off mass /kg	take-off distance /m	cruising speed km/h	fuel consumption litre/h	fuel capacity /litre	range /km	wing surface area /m^2
Airbus A340-300	4	152	284 000	3400	876	8000	155 400	13 500	362
Airbus A340-600	4	276	365 000	3200	902	9800	195 600	13 900	437
Boeing 777-200	2	343	247 000	3100	900	7700	117 300	9000	430
Boeing 747-400	4	264	397 000	3600	925	14 160	216 800	13 500	525
DC10-40	3	236	251 700	2800	965	10 800	138 700	9300	339
MD-11	3	270	273 900	3100	945	9000	146 000	12 600	339

Fig. 6

END OF ARTICLE