| Candidate Forename | | Candidate Surname | |
|---|---|---|---|

| Centre Number | | | | | | Candidate Number | | | | |
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# OXFORD CAMBRIDGE AND RSA EXAMINATIONS
## ADVANCED SUBSIDIARY GCE
# G492
# PHYSICS B (ADVANCING PHYSICS)
## Unit G492: Understanding Processes/
## Experimentation and Data Handling

**WEDNESDAY 13 JANUARY 2010: Morning**
**DURATION: 2 hours**

**SUITABLE FOR VISUALLY IMPAIRED CANDIDATES**

**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)**

**READ INSTRUCTIONS OVERLEAF**

DC (AC/CGW) MEP10268 24710/1

## INSTRUCTIONS TO CANDIDATES

- **Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes on the first page.**
- **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.**
- **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.**

- **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.**

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

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

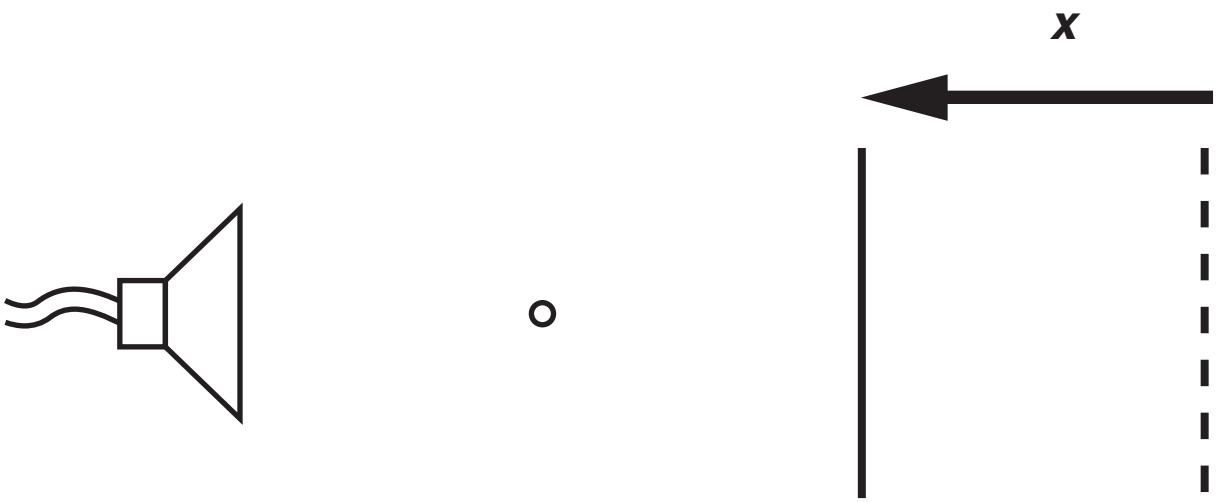
_____ **[1]**

**(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 <u>MINIMUM</u>.**




**Which of the following is the value of *x* in terms of the wavelength $\lambda$ of the sound?**

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

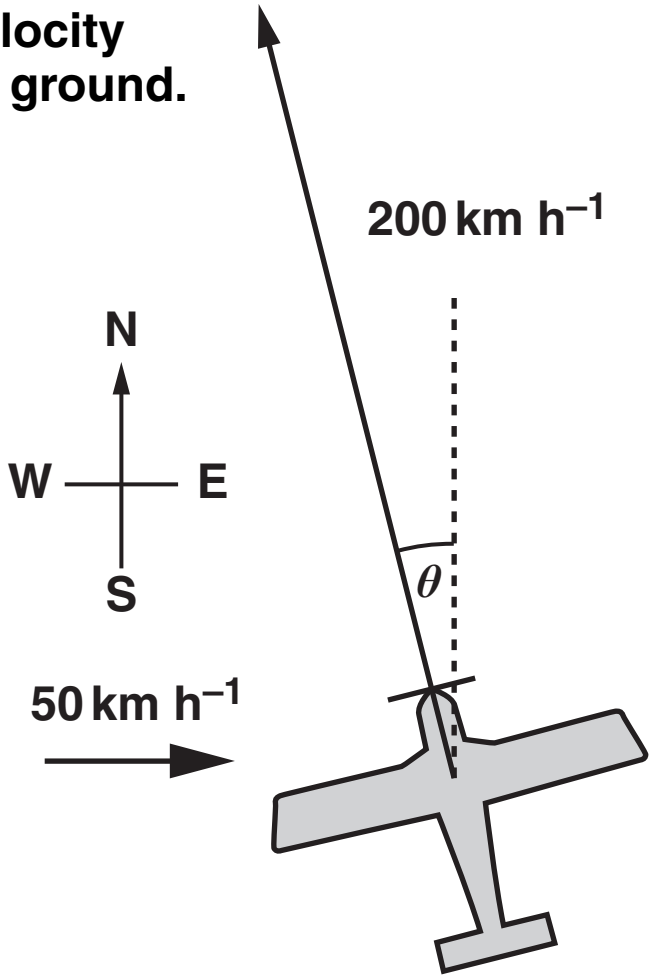
***x*** **= _____ [1]**

**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 $\theta$, west of north, which it must take.**

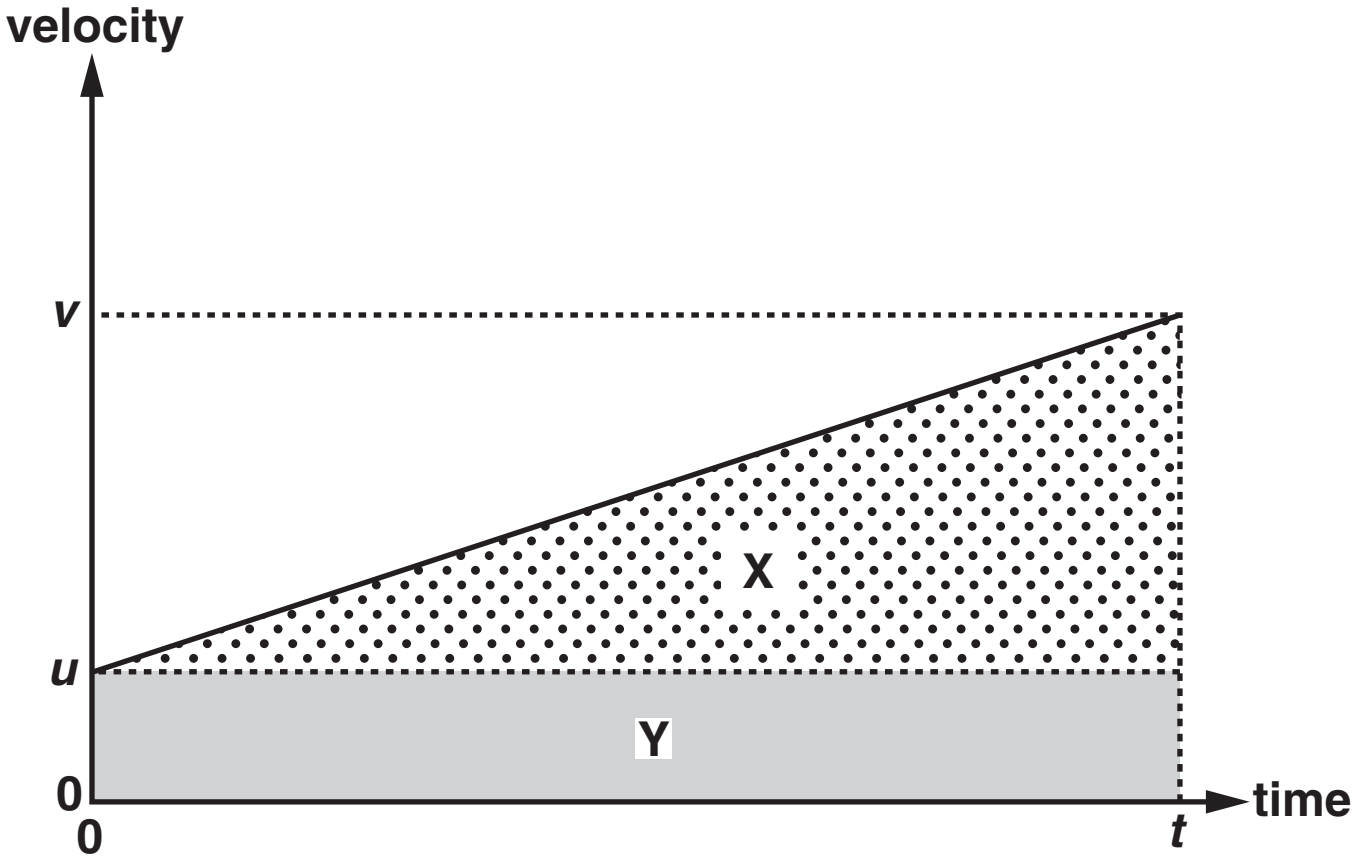
**Show your working clearly. You may wish to draw a vector diagram.**




***v*** **= _____ km h$^{-1}$**

**$\theta$ = _____ °W of N [3]**

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



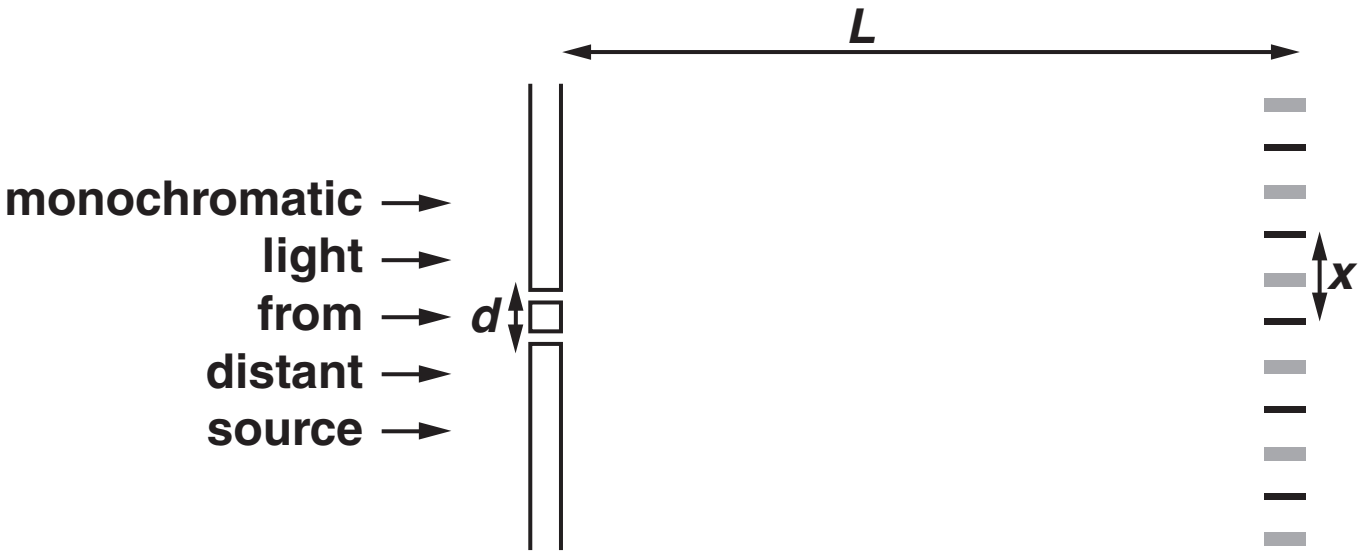

**Which of the following statements about the areas X and Y are correct?**

**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 $3.5 \times 10^{-19}$ J.**

**(a) Calculate the frequency of this radiation.**

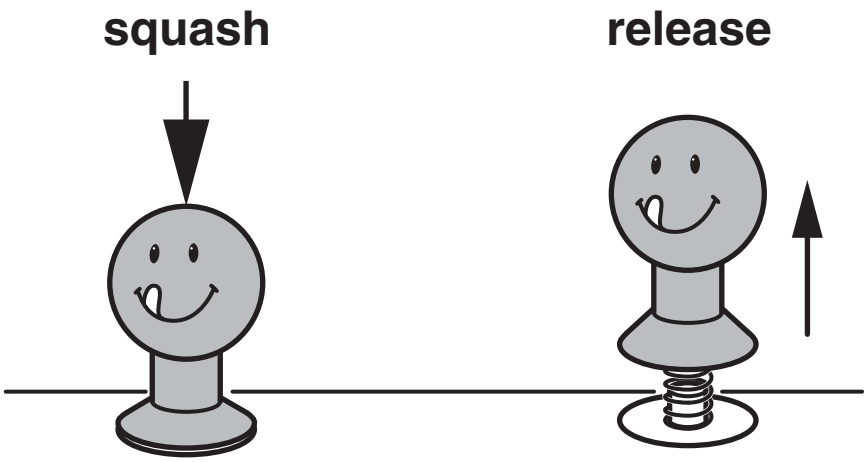
**the Planck constant $h = 6.6 \times 10^{-34}$ J s**

**frequency = _____ Hz [2]**

**(b) Calculate the output power of the LED when it emits $1.2 \times 10^{17}$ 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 $6.0 \times 10^{-3}$ 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 opposite, is the velocity-time graph for Usain in one of these two races.**

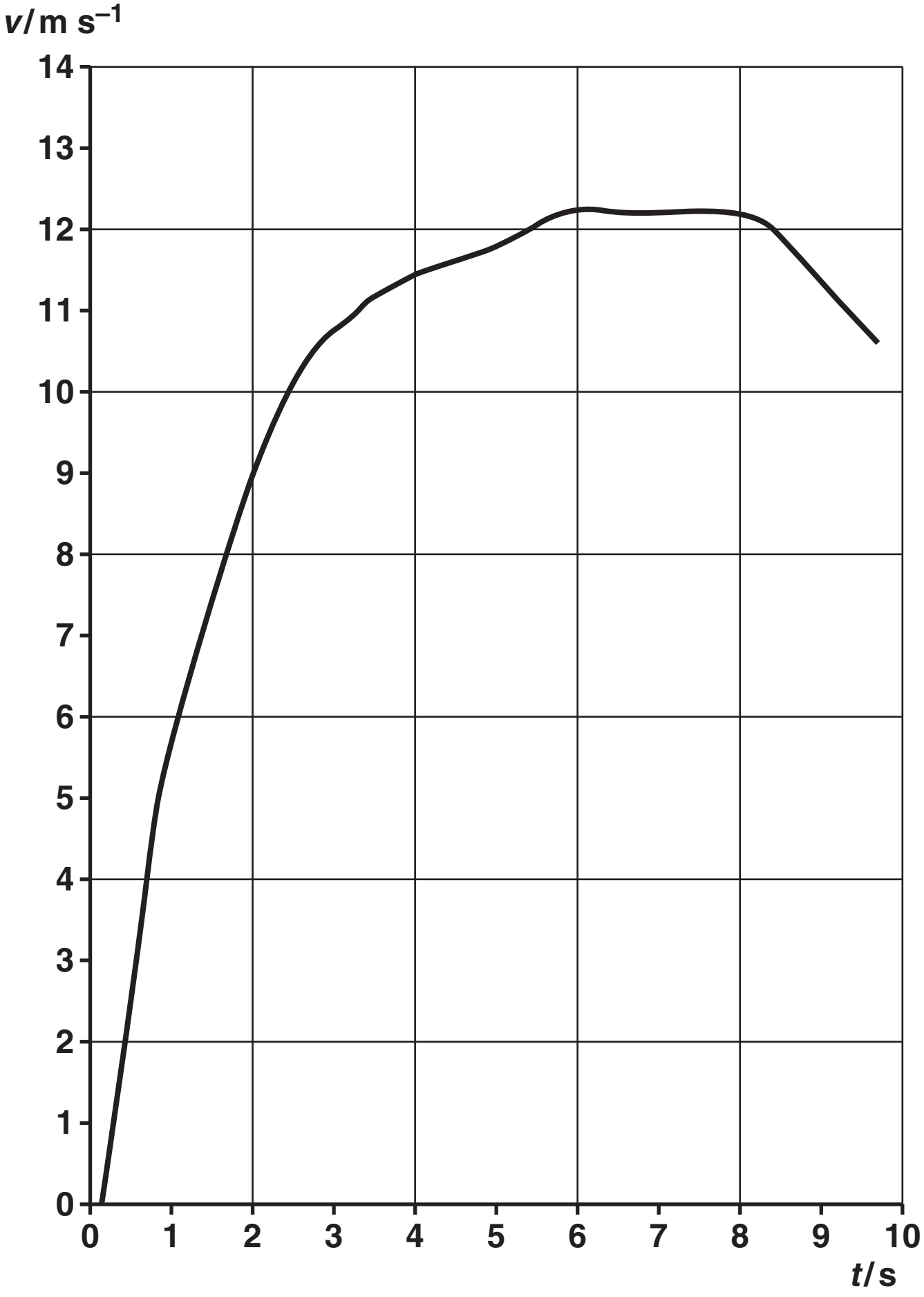



**Fig. 8.1**

**(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 opposite. This spectrum consists of six sharp lines, labelled A to F, each one corresponding to a single wavelength.**

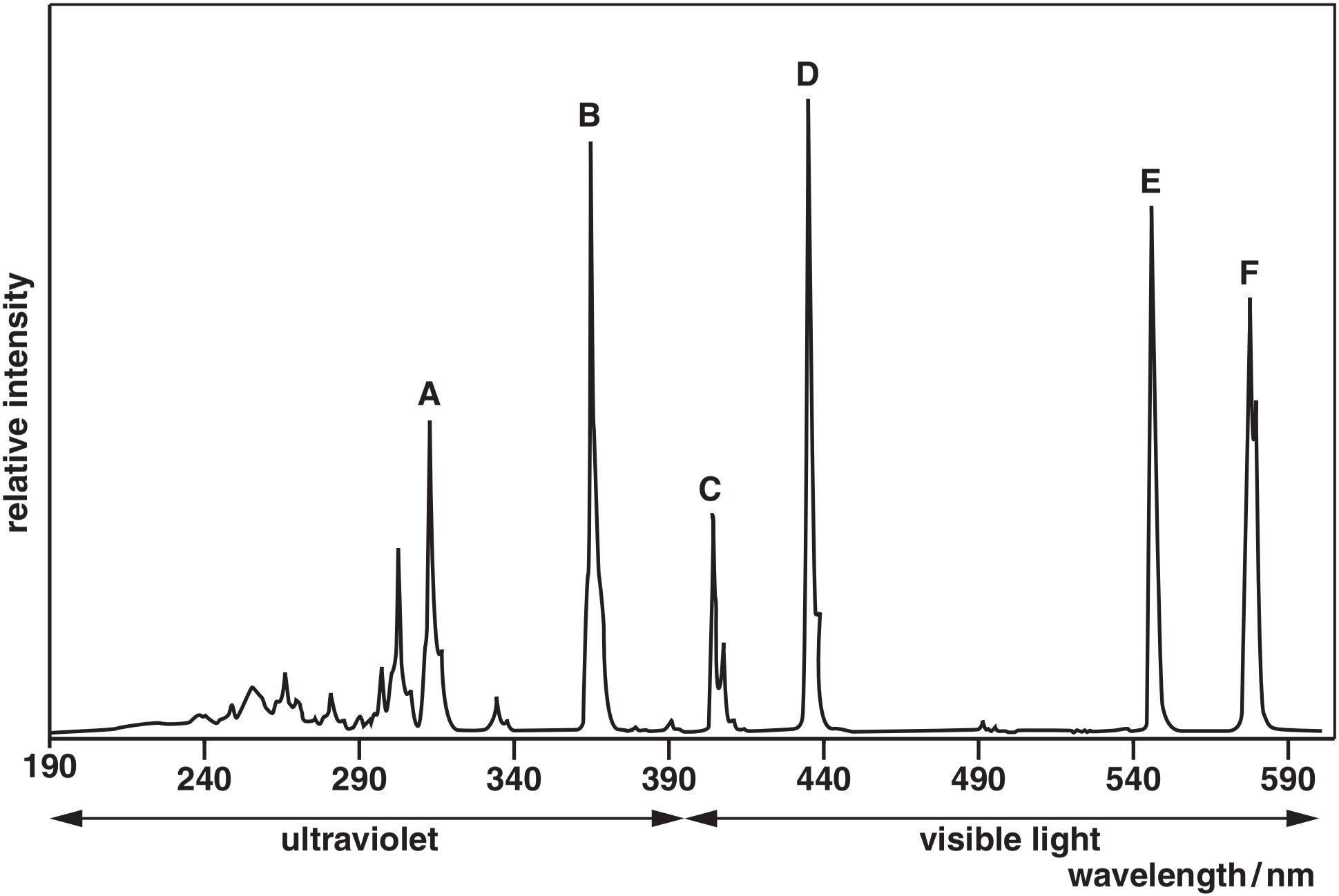

relative intensity
A
B
C
D
E
F
190
240
290
340
390
440
490
540
590
ultraviolet
visible light
wavelength / nm

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 <u>ONE</u> 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.**

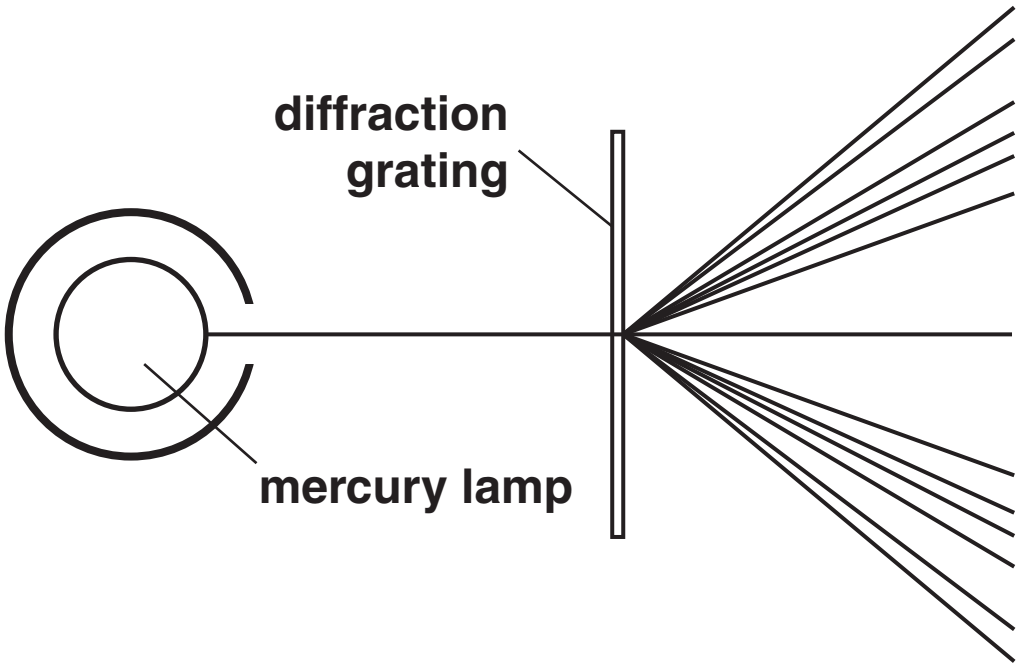



**Fig. 9.2**

**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 $5 \times 10^{-19}$ 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 $4.7 \times 10^{-19}$ 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, a long wooden tube which produces a note when it is blown into (Fig. 10.1).**

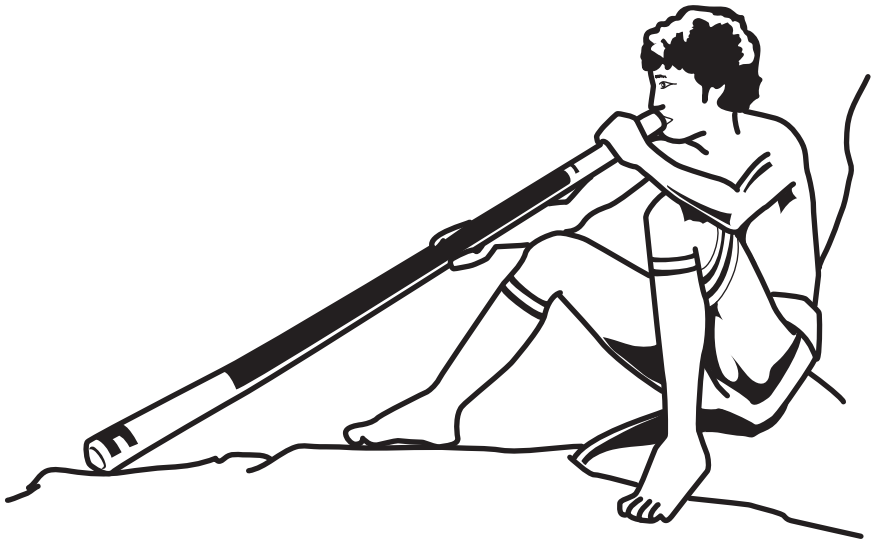


**Fig. 10.1**

**(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.**

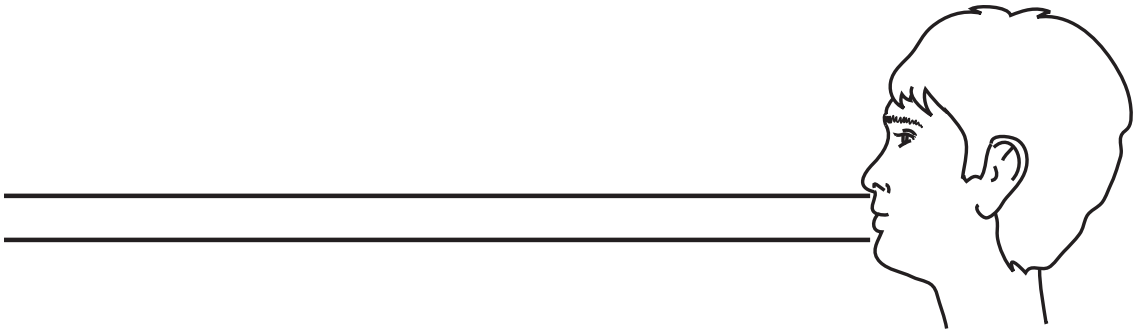


**Fig. 10.2**

**[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 m s$^{-1}$.**
**In this model, equal time intervals of 0.2 seconds are used.**

**(a) Explain why the horizontal displacement $\Delta x$ 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.**

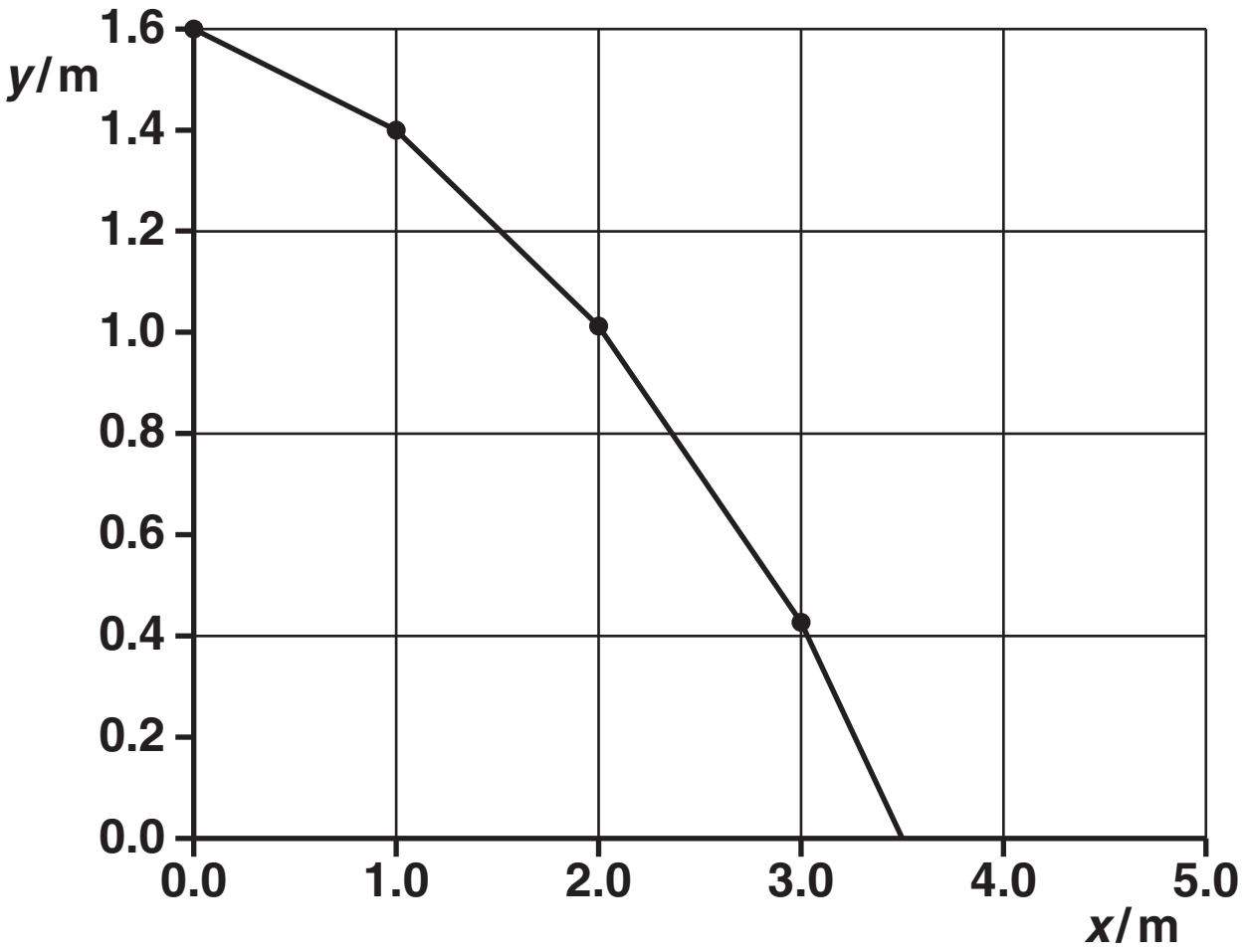



**Fig. 11.1**

**(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.**

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

**[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).**

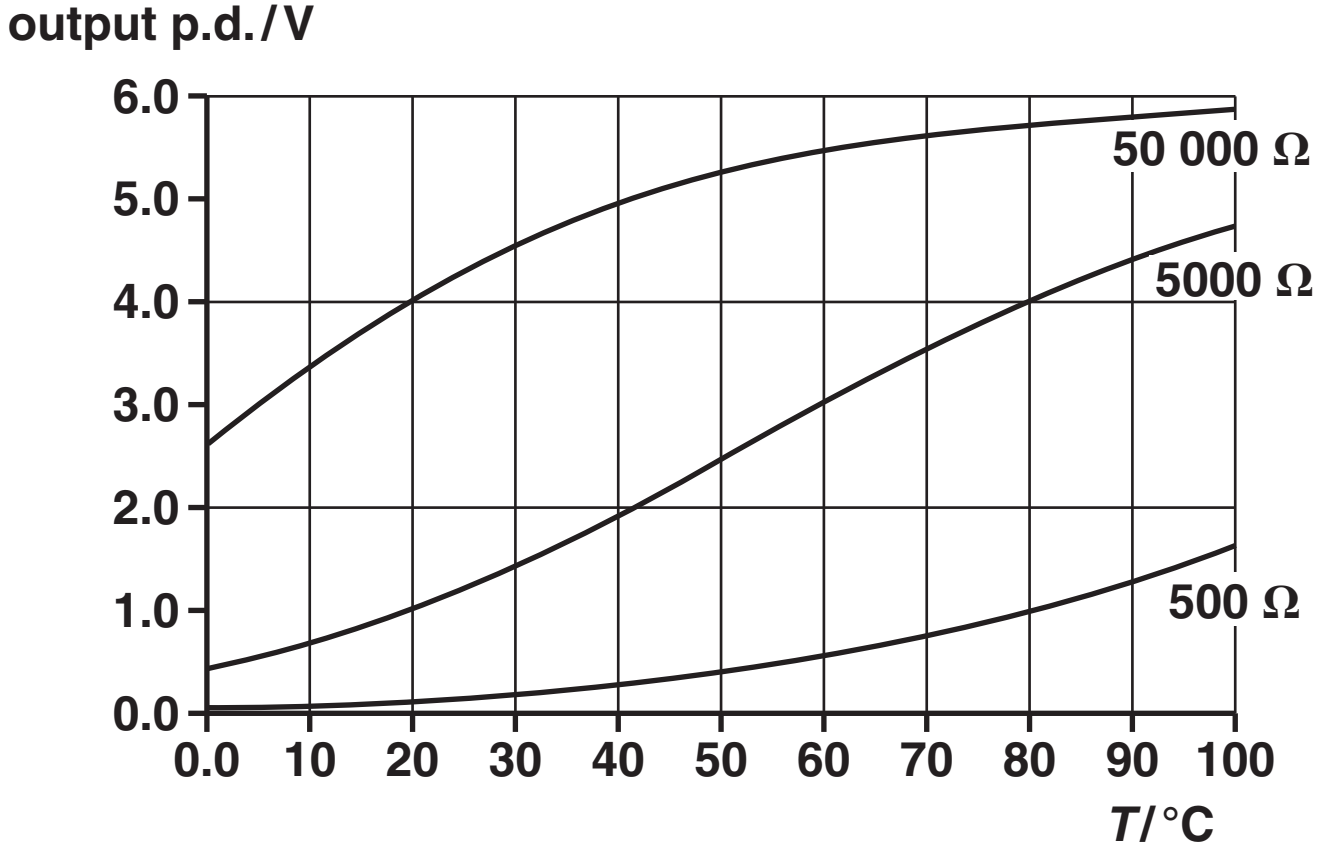



**Fig. 12.1**

**(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.**

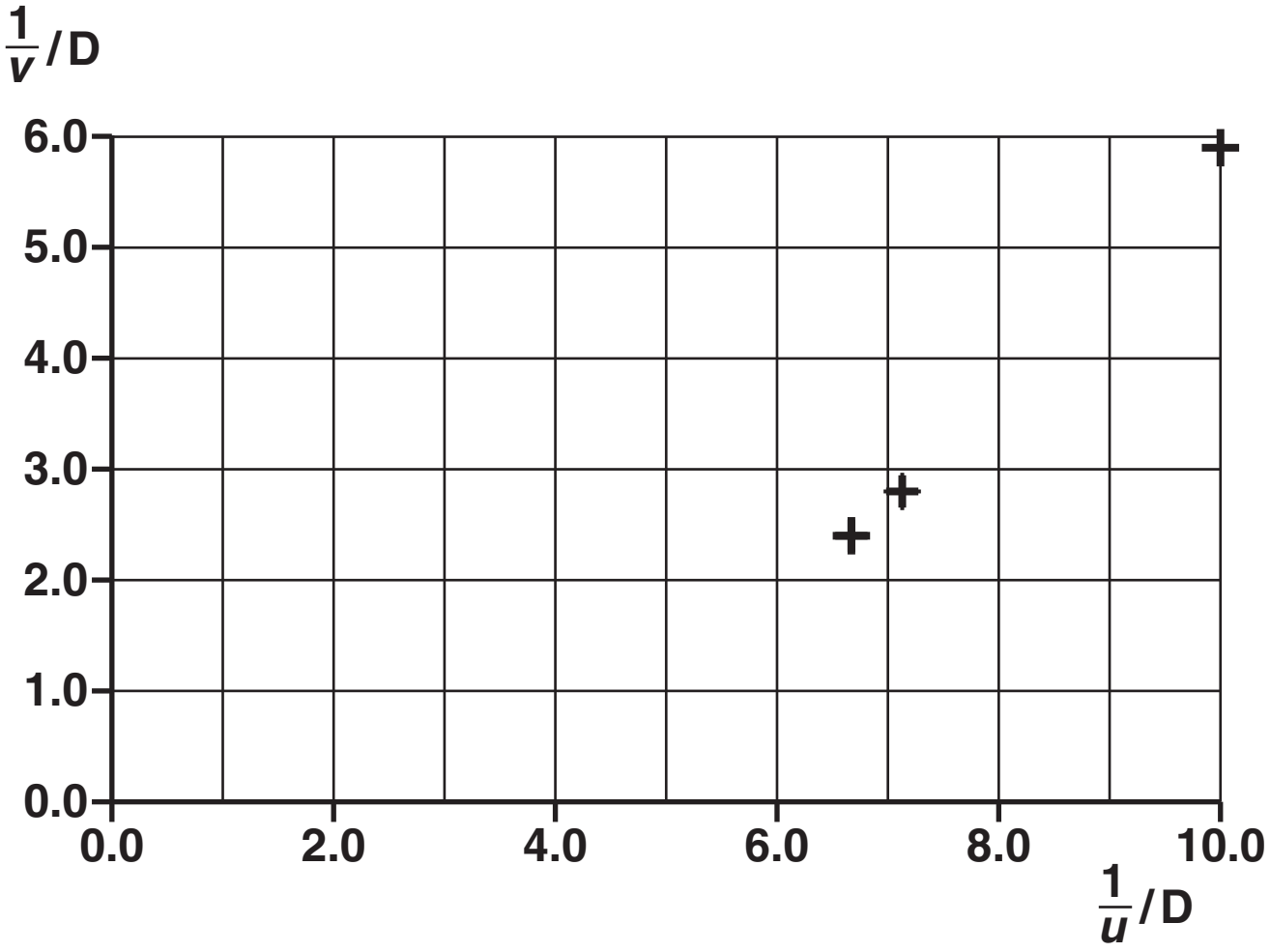


**Fig. 13.1**

**[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]**

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**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 $3\,m\,s^{-2}$.**

**[2]**

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

**[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 <u>MASS</u> 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.**

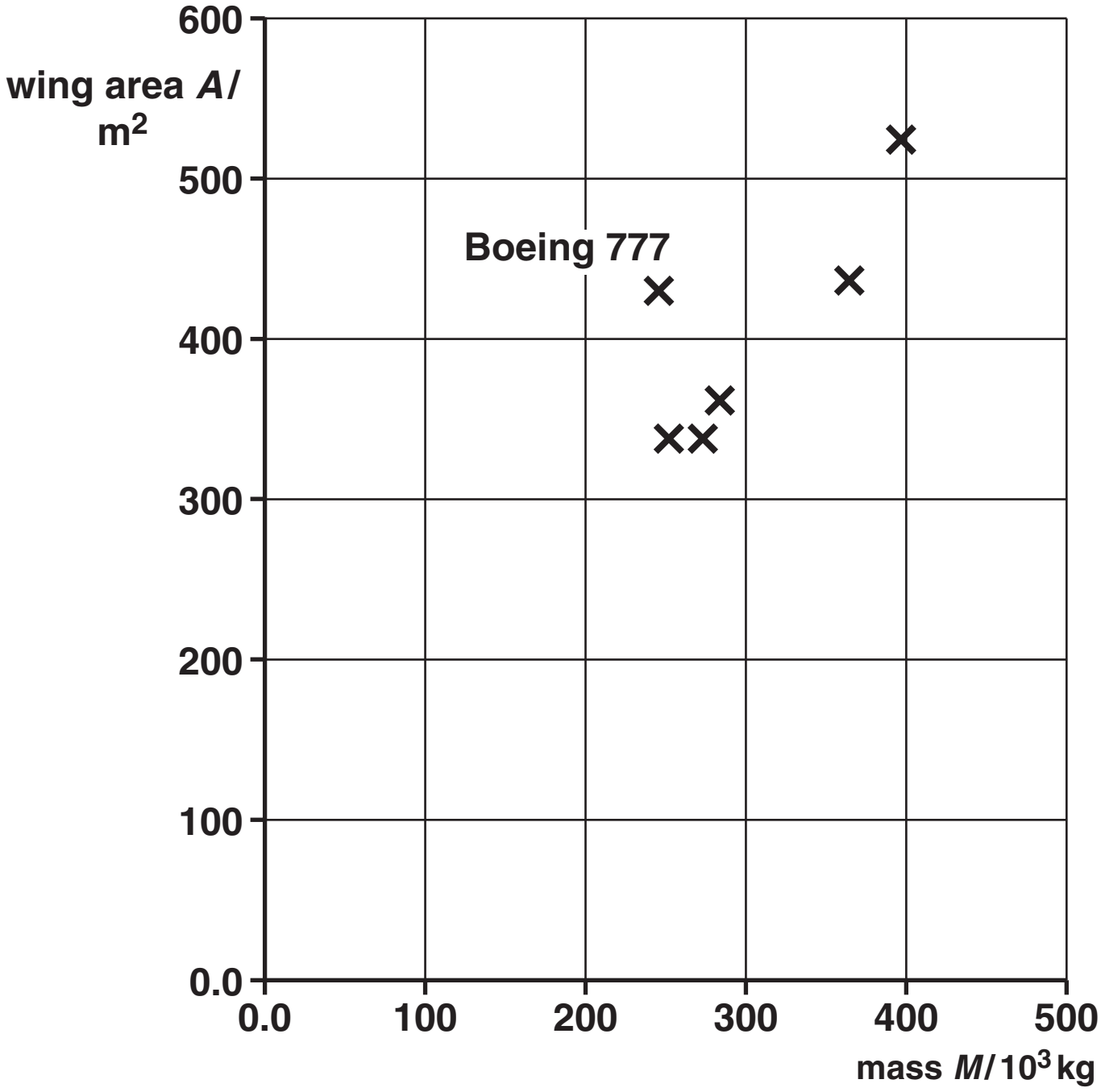


**Fig. 14.1**

**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]**

**END OF QUESTION PAPER**