OCR
Oxford Cambridge and RSA

Thursday 4 June 2015 – Afternoon

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 Relationships Booklet (sent with general stationery)

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

Duration: 2 hours

Candidate forename	SA Worked Ans	Candidate surname	Rough.

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert (Advance Notice) will be found inside this document.
- 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. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- 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.
- The questions in Section C are based on the material in the Insert.

Answer **all** the questions.

SECTION A

1 Here is a list of physical quantities.

displacement **force** **mass** **potential energy** **power**

(a) Which one could have the units $kg\,m\,s^{-2}$?

F = ma

force [1]

(b) Which of the quantities are vectors?

displacement & force [2]

2 The following five expressions represent familiar physical quantities in different situations. Each symbol has its usual meaning.

$$\frac{hc}{\lambda} \qquad d\sin\theta \qquad F\Delta s \qquad \frac{\Delta v}{\Delta t} \qquad \left(\frac{u+v}{2}\right)t$$

(a) Which **two** expressions represent energy?

hc/λ & $F\Delta s$ [2]

(b) Which **two** expressions represent distance?

$d\sin\theta$ & $\left(\frac{u+v}{2}\right)t$ [2]

3 Light of wavelength 590 nm is incident on a diffraction grating. The grating spacing is 2.8 μm.

(a) Calculate the angle of diffraction θ for the first order of diffraction from this grating.

$n\lambda = d\sin\theta \quad \therefore \quad \theta = \sin^{-1} \lambda/d$

$= \sin^{-1}\left(590\times10^{-9}/2.8\times10^{-6}\right) =$

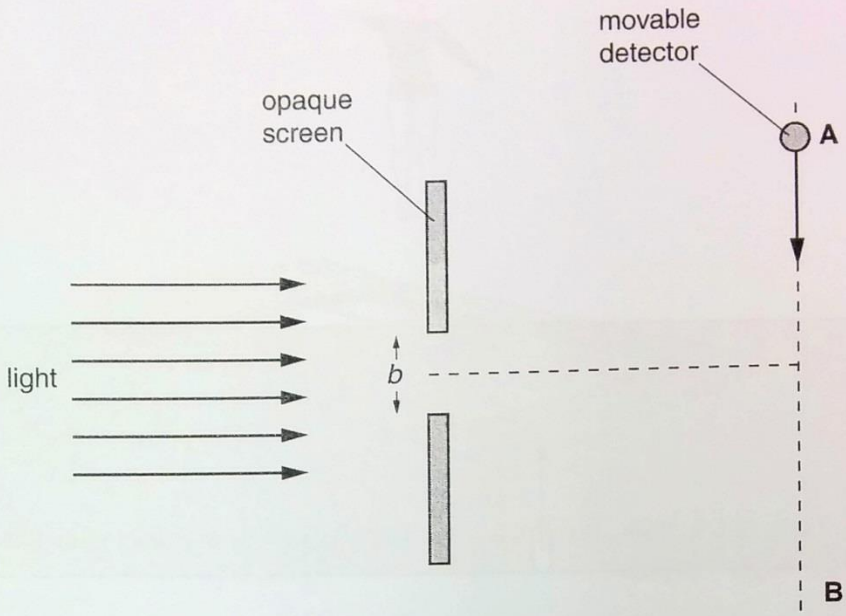
$\theta =$ 12.2 ° [2]

(b) There is also a diffraction maximum at an angle of 57.4°. Calculate the order n of diffraction which occurs at this angle.

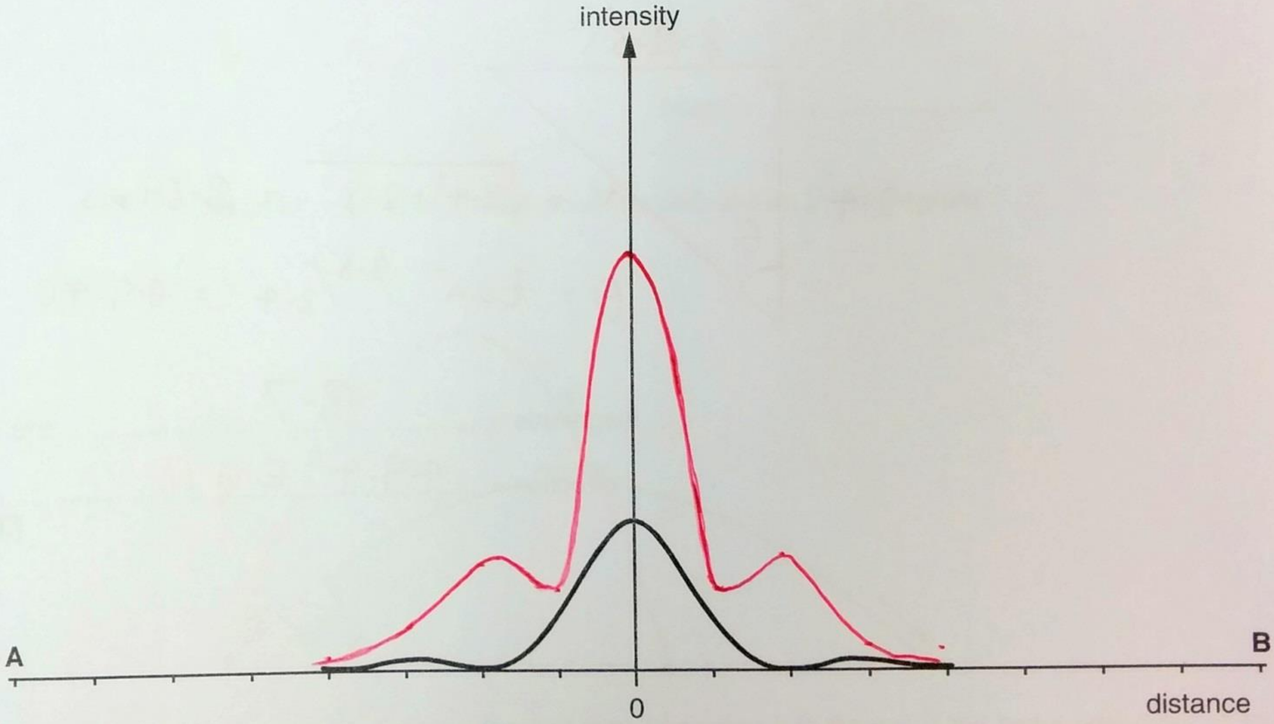
$n = \frac{d\sin\theta}{\lambda} = 2.8\times10^{-6}\sin 57.4 / 590\times10^{-9} =$

$n =$ 4 [2]

4 The diagram shows a parallel beam of light incident on an aperture of width *b* in an opaque screen. A detector on the other side of the aperture is moved from **A** to **B**.



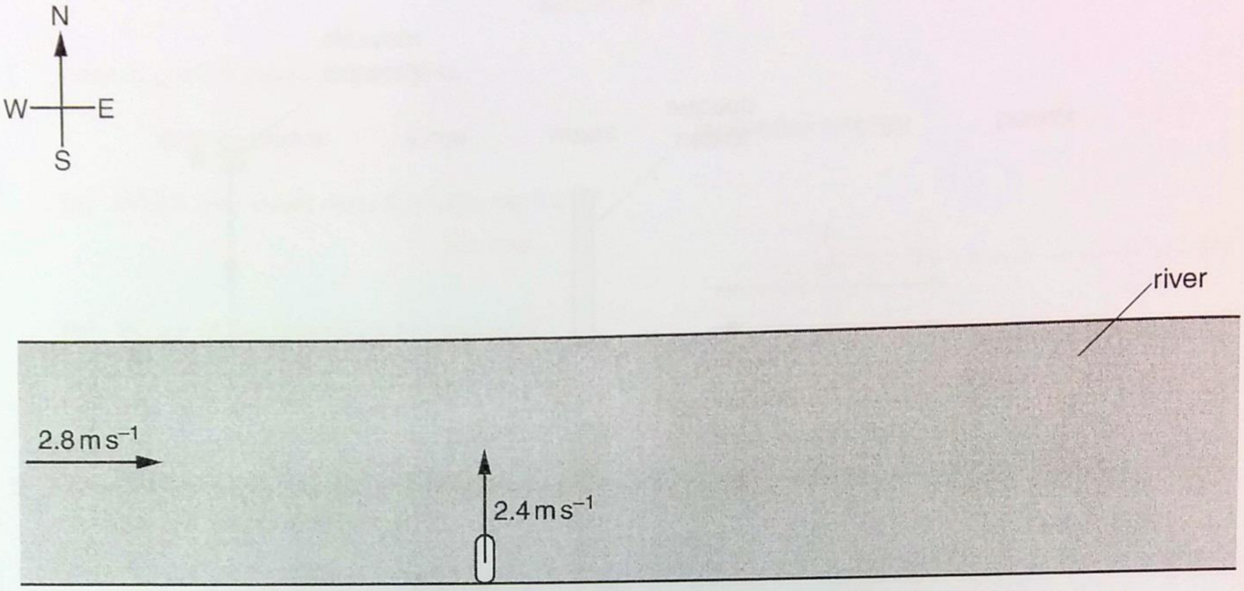
The detected intensity varies with distance as shown in the graph.



The width of the aperture is increased to 2*b*. The source of light remains the same.

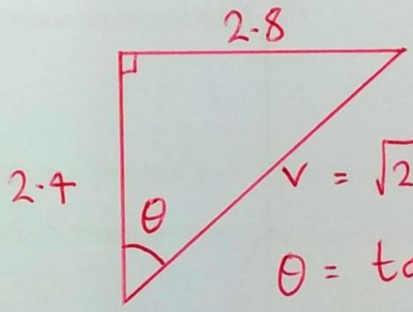
Sketch on the graph above the variation in intensity that would be expected. **[2]**

5 A boat heads out north to cross a river as shown in the diagram.



The boat moves at $2.4\,\text{m}\,\text{s}^{-1}$ in still water. The river is flowing due east at $2.8\,\text{m}\,\text{s}^{-1}$.

By scale drawing or by calculation, find the resultant velocity of the boat.



$v = \sqrt{2.4^2 + 2.8^2} = 3.69\,\text{ms}^{-1}$

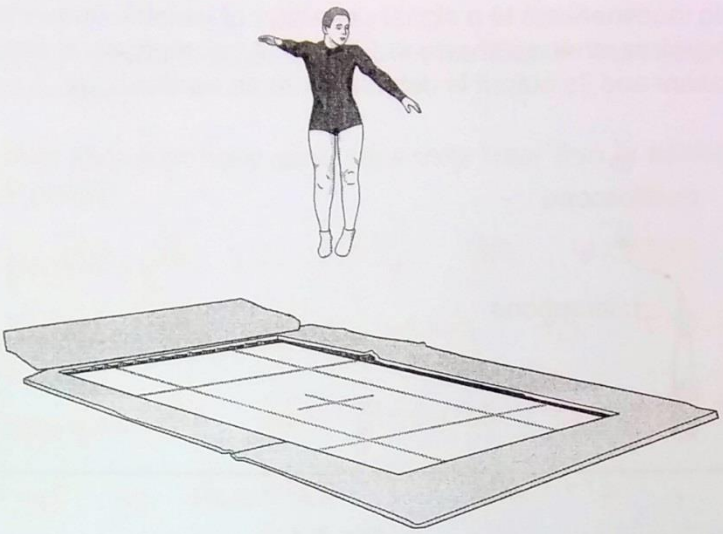
$\theta = \tan^{-1} 2.8/2.4 = 49.40$

magnitude = 3.7 $\text{m}\,\text{s}^{-1}$

direction = 49.4° E of N

[3]

6 A gymnast leaves the surface of a trampoline with an initial vertical velocity of $12\,\mathrm{m\,s^{-1}}$.



Calculate the height into the air that she rises. State any assumption that you make.

↳ no air resistance

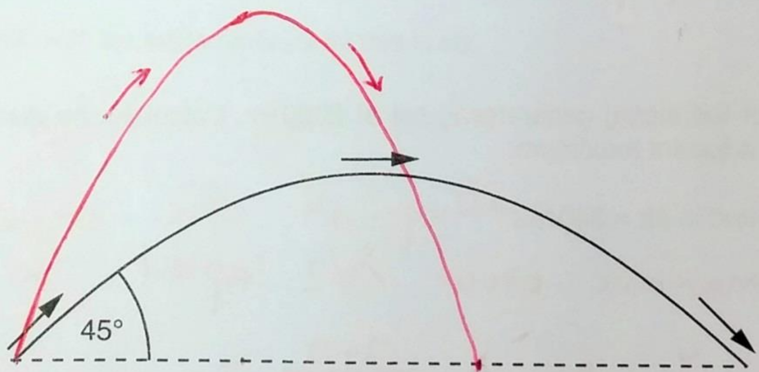
$g = 9.8\,\mathrm{m\,s^{-2}}$

$mgh = \frac{1}{2}mv^2$

$\therefore h = v^2/2g = 12^2/2 \times 9.8 = 7.347\,\mathrm{m}$

height = ...7.3...... m **[3]**

7 A ball thrown at 45° to the horizontal follows the path shown in the diagram.



On the diagram, sketch the path the ball may take when it is thrown at the same speed but at an angle greater than 45° (and less than 90°) to the horizontal. **[2]**

SECTION B

8 Tom connects two loudspeakers to a signal generator of variable frequency and then mounts them on a bench facing each other as shown in Fig. 8.1. A microphone is moved along the line joining the two loudspeakers and its output is detected with an oscilloscope.

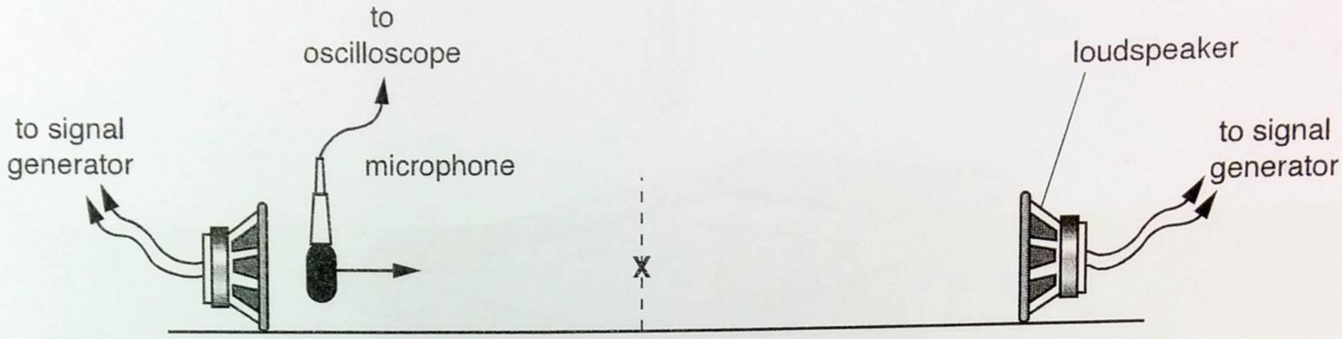


Fig. 8.1

(a) It is observed that the sound level detected by the microphone varies. The sound level is at a maximum at several places, including the position **X**, mid-way between the two loudspeakers. Explain why the sound level varies and why it is a maximum mid-way between the two loudspeakers.

Standing waves are produced as identical waves travelling in opposite directions superpose. At X the waves are in phase and superpose constructively to form an antinode. This is because the path length is the same at X.

[3]

(b) The frequency of the signal generator is set at 2000 Hz. Calculate the distance between **X** and the nearest adjacent maximum.

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

Adjacent maxima occur $\lambda/2$ apart so

distance $= \frac{v}{f} \times \frac{1}{2} = \frac{340}{2 \times 2000} =$

distance = 0.085 m **[2]**

(c) Sam uses the same signal generator and loudspeakers to set up this experiment, but her observations are different from Tom's.

(i) The distance between adjacent maxima in Sam's experiment is half the distance calculated in **(b)**.

Explain what she must have done differently from Tom in setting up the experiment to obtain this result.

The wavelength is half so either
i) doubled the frequency to 4000 Hz
ii) changed the air pressure / composition so the speed is doubled to 680 ms^{-1}. (Not on markscheme)

[2]

(ii) Sam observes that the sound level is a minimum, not a maximum, at the central point **X**.

State what this observation tells you about the waves leaving the two loudspeakers.

They are in antiphase (180° out of phase)

[1]

(d) The experiment is repeated outdoors. It is found that the variation of the sound level is much easier to detect than in the laboratory.

Suggest, with an explanation, why this is so.

No reflections from walls & ceiling which interfere with the pattern.

[2]

9 Standard 50 W filament lamps are often replaced by LED lamps such as the one shown in Fig. 9.1.

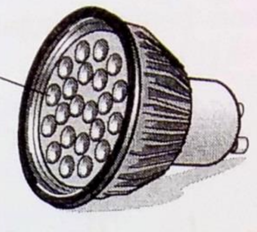


Fig. 9.1

(a) The power consumption of the set of 22 LEDs is 5 W.

(i) Calculate the number of photons emitted by **one** LED each second.
Assume that the mean photon frequency is 5.0×10^{14} Hz and that the energy efficiency is 100%.

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

$E = hf = 6.6 \times 10^{-34} \times 5 \times 10^{14} = 3.3 \times 10^{-19}$ J

$P = 5/22 = 0.227$ J/s

$\therefore$ number of photons/sec $= 0.227 / 3.3 \times 10^{-19}$

number = 6.89×10^{17} s^{-1} **[3]**

(ii) The 5 W LED lamp has the same brightness as the 50 W filament lamp.
For both lamps, virtually all the power input is radiated as photons of electromagnetic radiation.

Explain what this implies about the nature of the photons emitted by the filament lamp.

Most of the output of the filament lamp is not visible - it emits lower energy infra-red photons.

[2]

(b) The photons emitted by the LED lamp are not all of the same wavelength and frequency. The variation of power emitted with wavelength is given in Fig. 9.2.

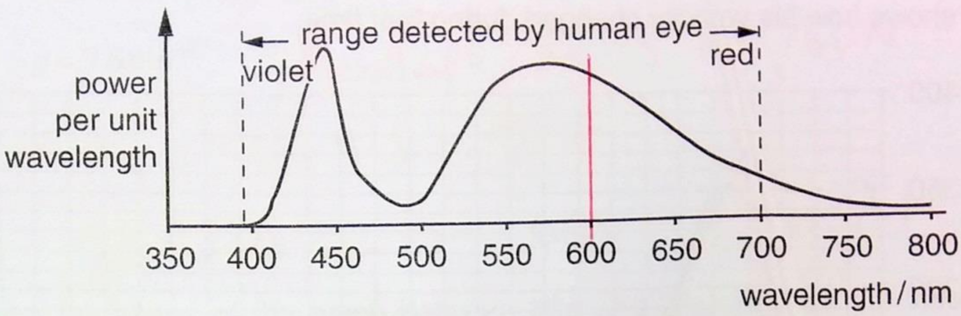


Fig. 9.2

In **(a)(i)** it was assumed that the mean photon frequency is 5.0×10^{14} Hz.

Explain how Fig. 9.2 shows that 5.0×10^{14} Hz is **not** a very accurate estimate of the mean frequency of photons emitted by the LED.

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

$\lambda = c/f = 3\times10^8 / 5\times10^{14} = 600\text{ nm}$

The mean photon energy is less than this at around 550 nm.

[2]

(c) The manufacturers of the lamp giving the spectrum of Fig. 9.2 produce a similar lamp which emits light with the spectrum shown in Fig. 9.3.

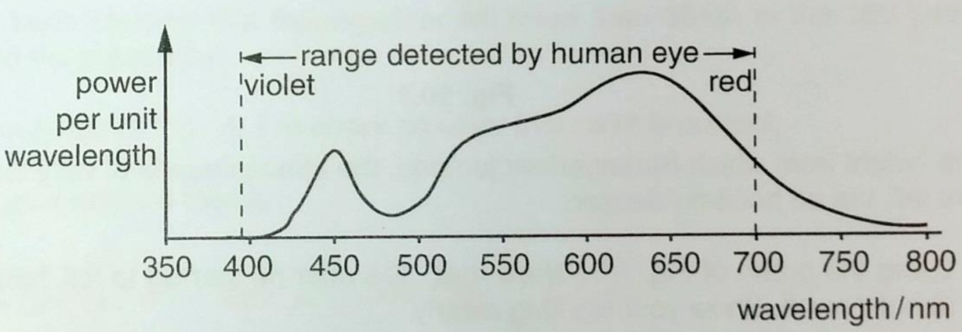


Fig. 9.3

Explain how, viewing the light emitted by both lamps, you are able to tell which lamp produced the spectrum shown in Fig. 9.3, and suggest an environment for which it would be more suitable than the other.

The lamp in 9.3 will look warmer/redder so is more suitable for living space.

[2]

10 In October 2012, the Austrian skydiver Felix Baumgartner jumped from a balloon more than 36 km above the Earth's surface. He fell freely for over four minutes before opening his parachute.

Fig. 10.1 shows how his velocity changed during that time.

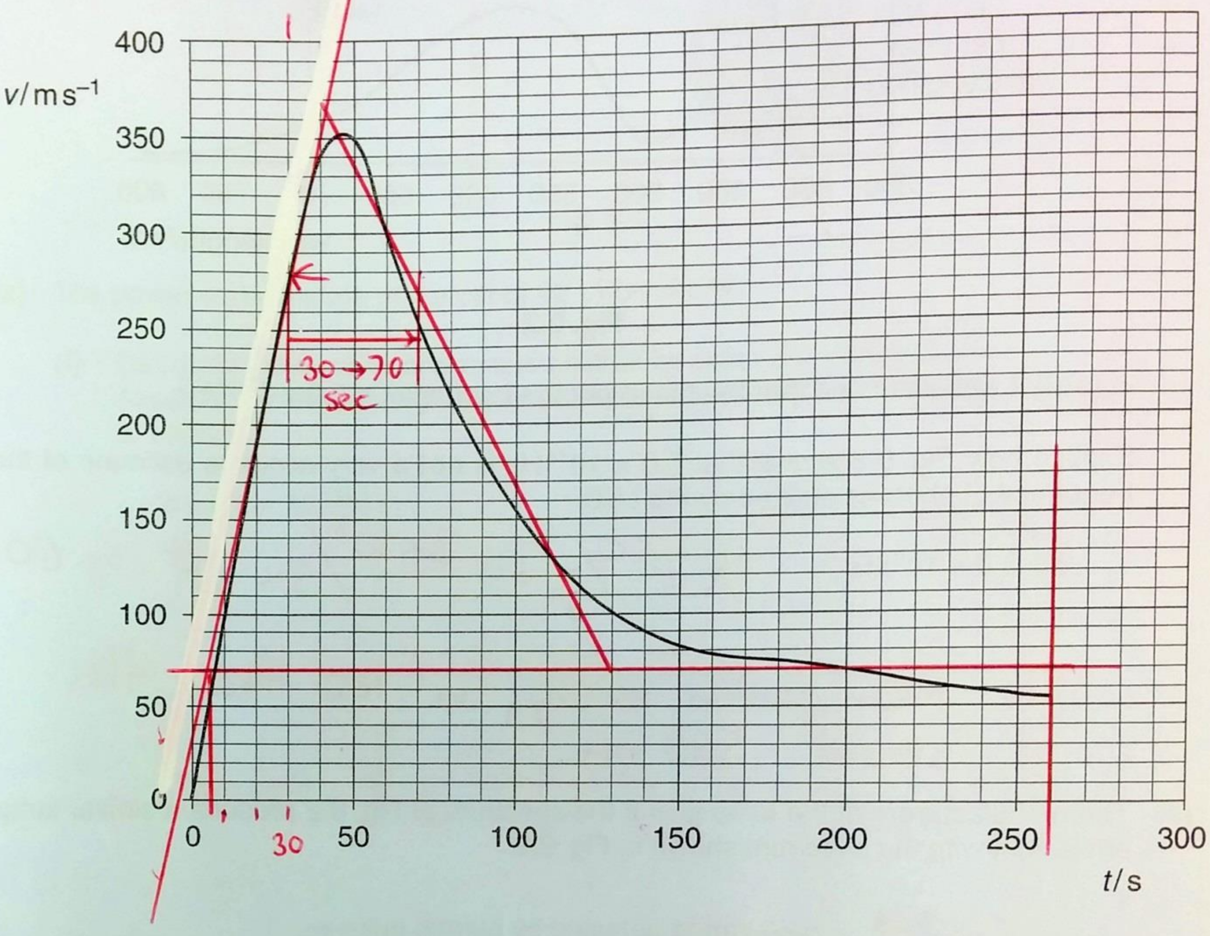


Fig. 10.1

(a) At the height from which Baumgartner jumped, the atmosphere is of very low density. As he fell, the air became denser.

(i) Using the graph of Fig. 10.1 show that, 30 s after he started to fall, his acceleration was about 7 m s^{-2}. Show your working clearly.

Acceleration = gradient of tangent at 30 s

$$\frac{400-40}{45} = 8\,\text{ms}^{-2}$$

(6–9 allowed)

[2]

(ii) Calculate the upward force *F* acting on Baumgartner at this point.

total mass of Baumgartner = 95 kg

$g = 9.8\,\text{m}\,\text{s}^{-2}$ $F_{resultant} = 8 \times 95 = 760\,N$

$W = mg = 95 \times 9.8 = 931\,N$

$\therefore F = 931 - 760 =$ force = ...171...... N **[3]**

(b) Describe the shape of the graph between 30 s and 70 s. Explain the velocity changes in terms of changes in the air through which Baumgartner was falling. You may wish to label any point(s) of interest on Fig. 10.1.

Velocity rises to maximum due to acceleration due to gravity & then begins to fall as air resistance increases due to the rising air density/pressure as Felix's altitude decreases.

[3]

(c) It has been claimed that Baumgartner fell more than 35 km in the 260 seconds before he opened the parachute.

Use the graph of Fig. 10.1 to check whether this claim is correct.

Show your method clearly.

Distance = area under curve.

$= 255 \times 70 + \frac{1}{2} \times 125 \times 290 = 36\,km$

so yes.

34–36 for 2

[3]

11 This question is about the energy losses from a moving vehicle caused by forcing the air in front of it out of its way.

Fig. 11.1 shows a bus moving at a constant velocity v along a straight, level road through still air. The bus is modelled as having a uniform cross-section.

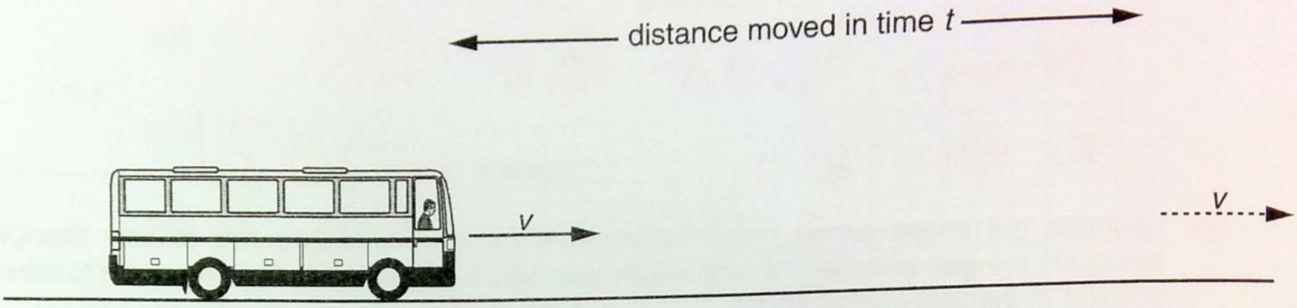


Fig. 11.1

The effects of a streamlined shape on the drag forces have been ignored in this model.

(a) The cross-sectional area of the bus is A.
Use appropriate algebraic equations to explain why the mass m of air displaced by the bus in a time t is given by

$$m = \rho A v t$$

where ρ is the density of the air.

distance travelled = vt

∴ volume of air = Avt

$m = \rho \times V$ ∴ mass = $\rho A v t$

[2]

(b) In this model, the air displaced by the bus is forced to move at the same speed v as the bus. Show that the kinetic energy E_K gained by the air displaced in a time t is given by

$$E_K = ½\,\rho A v^3 t.$$

$$E_K = \frac{mv^2}{2} = \frac{\rho A v t v^2}{2} = \frac{1}{2}\rho A v^3 t$$

[1]

(c) Use the equation given in **(b)** to calculate the power dissipated into the air when a bus of cross-sectional area 9.0 m^2 travels at a constant speed of 20 m s^{-1}.

$\rho = 1.2\,\text{kg m}^{-3}$

$P = E/t = \dfrac{\frac{1}{2} \times 1.2 \times 9.0 \times 1 \times 20^3}{1} =$

power = 43200 W **[2]**

(d) A typical car carries two or three people while a typical coach carries 45 people (Fig. 11.2).

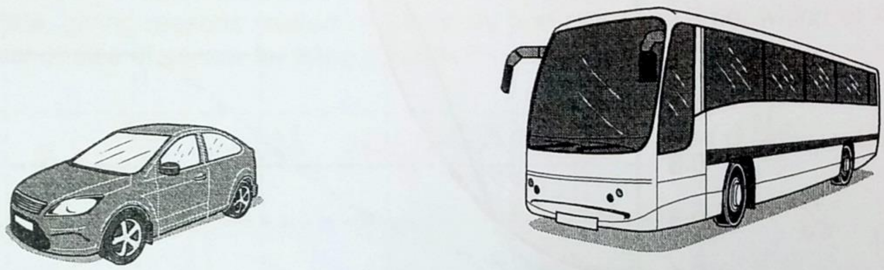


Fig. 11.2

Discuss the advantages and disadvantages of travelling between towns by these different methods.

In your answer, you should include comparisons of energy losses and other factors of importance for travellers.

Power lost per person greater for coach as it carries 45/2.5 = 18x more people but its cross-sectional area is around 4x larger.

However although more fuel efficient the coach is likely to be slower and only leaves at fixed times.

[4]

SECTION C

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

12 This question is about the article *The response time of thermistors.*

When the sensors were all plunged into the hot water at time $t = 0$ as described in the article the results were as follows.

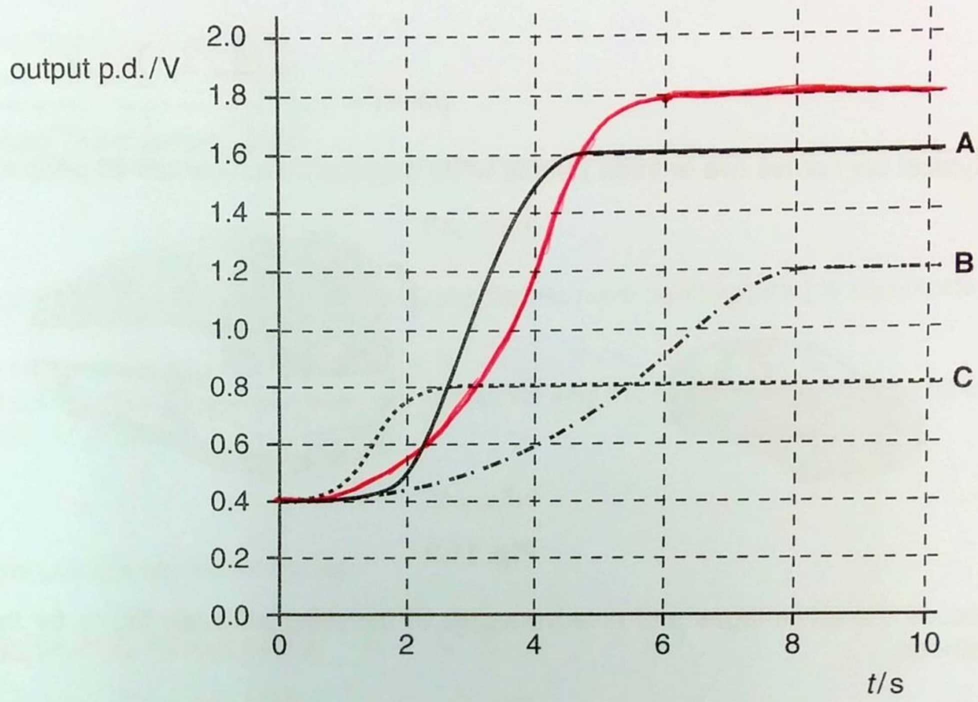


Fig. 12.1

(a) **(i)** State the sensor with the shortest response time.

C ....

State the sensor with the longest response time.

B ....

[1]

(ii) State the sensor with the greatest sensitivity.

A ....

State the sensor with the least sensitivity.

C ....

[1]

(b) The temperature rise was 50 °C for all sensors.

Calculate the sensitivity of sensor **A**.

sensitivity = $\Delta V / \Delta \theta$ = $\frac{1.6 - 0.4}{50}$ =

sensitivity of sensor **A** = ...0.024...... unit ......$V°C^{-1}$...... **[3]**

or VK^{-1}

(c) A sensor is needed to provide an early warning system in a baby incubator to prevent overheating.

(i) State, giving reasons related to sensitivity and response time, which of **A**, **B** or **C** is the best choice of sensor for this purpose.

A as it will respond to smaller changes and its responce time of ~4s is fine.

[2]

(ii) Draw one additional line on Fig. 12.1 to represent a sensor which, when exposed to a 50 °C temperature rise, has a response time between that of sensors **A** and **B** and greater sensitivity than all of the other three sensors. You can assume that the output p.d. of the new sensor is 0.4 V at room temperature. **[3]**

13 This question is about the article *Electricity consumption in an American home.*

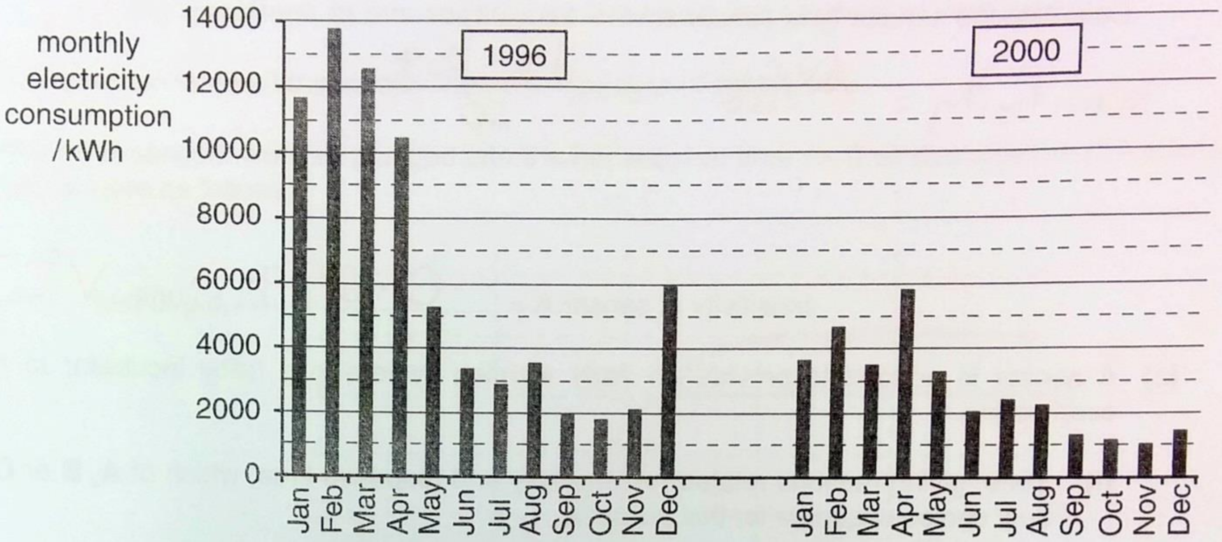


Fig. 13.1

(a) Discuss the effect on the monthly electricity consumption of the changes made in 1998.

In your answer, use data from Fig. 13.1 and Tables 1 and 2 in the article.
In this part, you should ignore any changes in the number of people living in the house.

Total energy consumption is lower and is also lower each month.
There are bigger savings in the winter.

e.g. Feb $\frac{13800}{4800}$ = 2·9 x less

August $\frac{3500}{2100}$ = 1·7 x less

(b) Use data from Tables 1 and 2 in the article to calculate the energy reduction in joules between 1996 and 2000 for the month of May.

5280 − 3311 = 1969 kWh

1969 × 1000 × 3600 =

energy reduction = $7{\cdot}1 \times 10^9$ J **[2]**

(c) Fig. 13.2 uses data that take into account the number of people in the house.

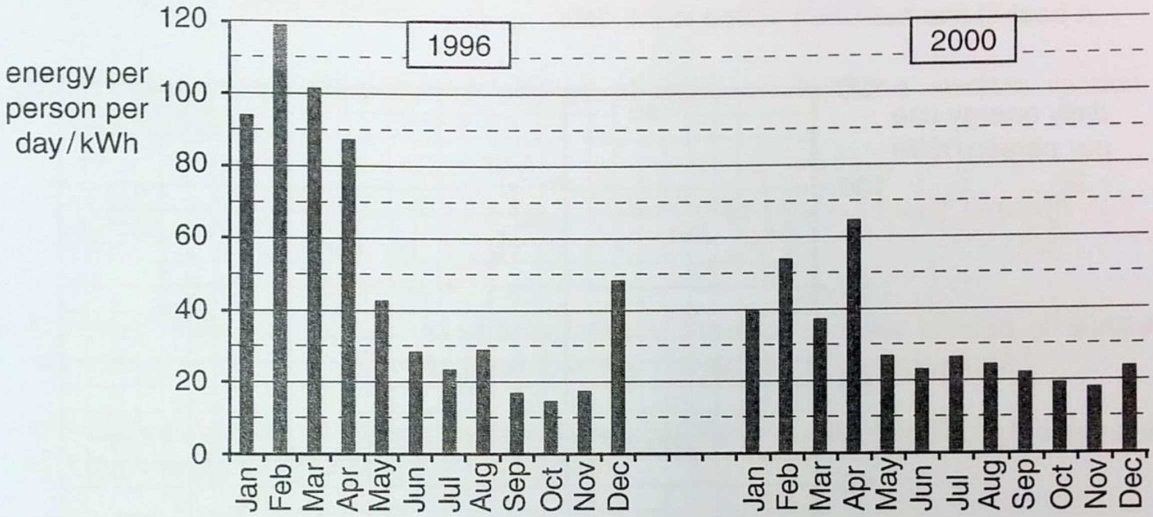


Fig. 13.2

(i) Give one reason for, and one reason against, taking the number of people into account.

F More people use more energy so fairer

A Some energy requirements are independent of the number of people. **[2]**

(ii) State **two** separate features of Fig. 13.2 that provide evidence that there were differences in average monthly **temperatures** between the two years.

Highest & Lowest consumption months are not the same.

[2]

(iii) The average monthly temperatures have not been recorded, only the long-term average over many years.

Explain why this makes the comparisons of the two data sets less straightforward.

The years tested may not have been typical which should be taken into account for valid data.

[2]

(d) Fig. 13.3 shows the relationship between temperature and daily energy use per person **in 1996** based on the thirty-year average monthly temperature data.

A best-fit line has been added to the data.

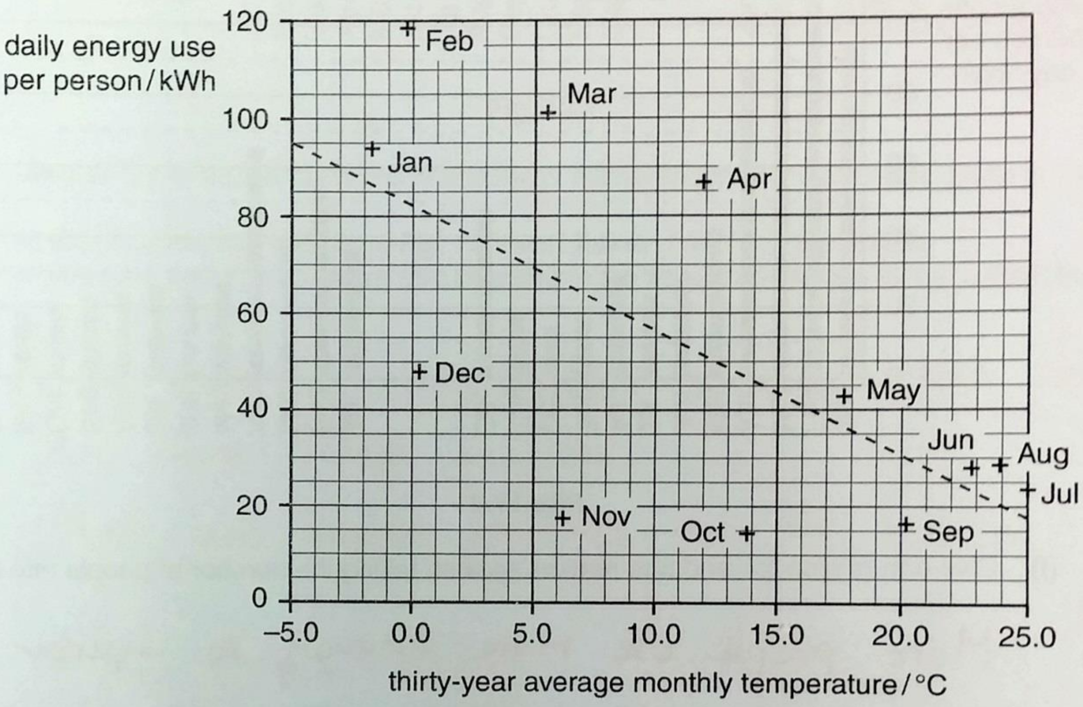


Fig. 13.3

Comment on the relationship between temperature and energy use shown by this graph.

Higher temperatures lead to lower energy consumption. It looks like air con does not use as much energy as heating. That said the data is quite scattered - the correlation is not that strong.

[3]

14 This question is about the article *Thomas Young's double slit experiment.*

(a) (i) Suggest, with reasons, why the wave theory of light was not widely accepted in Britain before Young's experiment.

Newton went for the particle theory and he carried great authority.

[2]

(ii) State and explain why in Young's original experiment the sunlight was passed through a tiny hole.

To produce a narrow beam

[1]

(iii) Suggest and explain **one** advantage of using a laser in a modern version of the experiment.

It has a single (almost) wavelength (also coherent)

[1]

(b) A student sets out Thomas Young's experiment but uses a laser instead of sunlight. The experiment is set up to calculate a value for the wavelength of the laser light.

The thickness of the stiff paper used to split the laser beam is calculated from the measurement of a stack of 40 identical pieces of stiff paper.

Explain how this method reduces the uncertainty compared with making a measurement of the thickness of a single piece of paper.

With 40 pieces of card the absolute uncertainty is divided by 40 thus reducing the % uncertainty.

(c) The following values are measured in the student's experiment:

thickness of paper, $d = 0.11 \pm 0.01$ mm = 9%

distance from paper to the screen, $L = 6.40 \pm 0.05$ m = 0.8 %

separation of fringes on the screen, $x = 2.4 \pm 0.1$ cm. = 4 %

(i) The student wrongly states that the percentage uncertainty in the wavelength is roughly equal to the percentage uncertainty in *x*, the separation of the fringes, because the other two percentage uncertainties are much smaller.

Comment on the student's statement.

Use calculations to support your answer. See above.

Largest uncertanty is in d = 9%

So uncertanty in λ is < than that in x

[3]

(ii) Use the equation $\lambda = \frac{xd}{L}$ and the student's measurements, to calculate a mean value for the wavelength.

$$\lambda = \frac{2.4 \times 10^{-2} \times 0.11 \times 10^{-3}}{6.40} =$$

$\lambda =$ 4.13×10^{-7} m **[2]**

(iii) Calculate the maximum value for the wavelength λ using the uncertainties quoted in the student's measurements.

$$\lambda_{max} = \frac{2.5\times10^{-2}\times0.12\times10^{-3}}{6.35} =$$

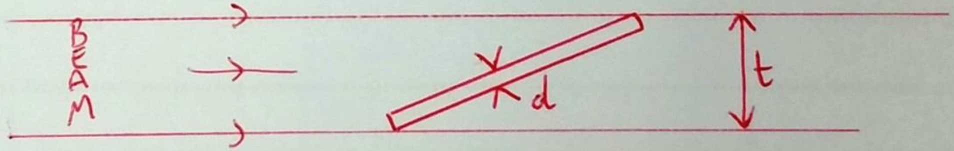
$\lambda_{maximum}$ = 4.72×10^{-7} m **[2]**

(iv) The value of $\lambda_{maximum}$ from the student's data is significantly lower than the manufacturer's value for the wavelength of the laser used in the experiment, which is 635 nm.

Explain how this value supports the statement in the article:
The systematic error introduced by placing the card at an angle to the beam could considerably exceed the uncertainties in measurements of the fringe separation and the thickness of the card.

The systematic error here is ≈ 635 − 472 = 163 ≈ 160 nm where as the uncertanty is arround 9% of 413 nm = 37 nm

If the card is at an angle then d can be much larger than the thickness of the card.



[3]

t >> d

value of d is too small → λ is too small

END OF QUESTION PAPER