Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

WJEC CBAC

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

541/01

PHYSICS

ASSESSMENT UNIT PH1: Waves, Light and Basics

A.M. FRIDAY, 10 June 2005

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the information "Mathematical Data and Relationships" on the back page of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

For Examiner's use only.	
1	
2	
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5	
6	
7	
Total	

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}6 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Mass of a proton	m_{p}	=	$1{\cdot}67 \times 10^{-27}$ kg
Molar gas constant	R	=	$8{\cdot}3$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}8$ m s^{-2}
[Gravitational field strength at sea level	g	=	$9{\cdot}8$ N kg^{-1}]
Universal constant of gravitation	G	=	$6{\cdot}7 \times 10^{-11}$ N m^2 kg^{-2}
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}$ J K^{-1}
Unified mass unit	1 u	=	$1{\cdot}66 \times 10^{-27}$ kg
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^8$ m s^{-1}
Permittivity of free space	ε_{o}	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_{o}	=	$4\pi \times 10^{-7}$ H m^{-1}

1. *(a)* A student gives the following **incorrect** statement for the principle of moments.

'For a body to remain in equilibrium the anticlockwise force must balance the clockwise force.'

Give a correct statement of the principle. [2]

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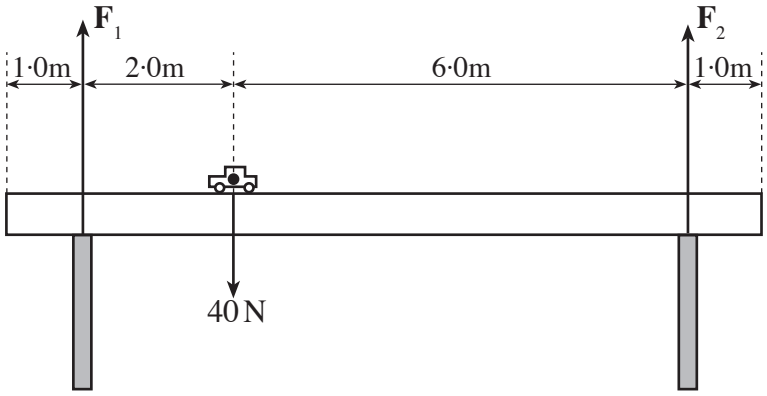
(b) The diagram shows a model bridge system used for testing structural strength using different loads. The bridge is a uniform rectangular block of weight 100 N. It carries a model car of weight 40 N. The upward forces acting on the bridge are labelled $\mathbf{F}_1$ and $\mathbf{F}_2$.



(i) Show, with an arrow, the weight of the bridge itself (100 N) acting through the Centre of Gravity of the bridge. [1]

(ii) By taking moments about a suitable point calculate F_2. [3]

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(iii) Hence calculate F_1. [2]

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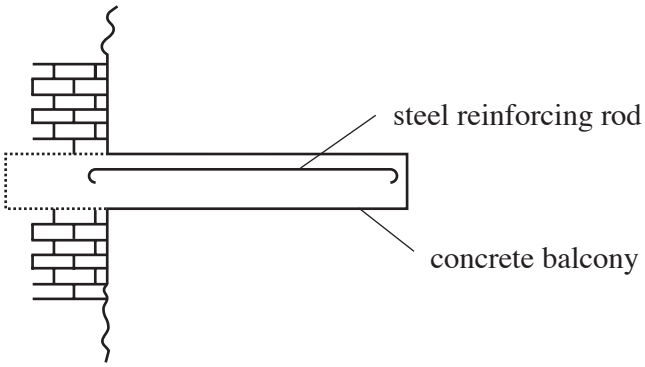
(iv) The car is moved to the left i.e. towards F_1. State, without further calculation, what happens to the value of

(I) F_1, ... [1]

(II) F_2. ..... [1]

2. The diagram shows the cross-section through a concrete balcony. It is reinforced with steel rods, one of which is positioned as shown.



(a) (i) On the diagram label the surface (upper or lower) of the balcony that is

(I) in tension (label with T), [1]

(II) in compression (label with C). [1]

(ii) Explain why the steel reinforcing rod is positioned as shown near the upper surface. Your answer should make reference to the tensile properties of both concrete and steel and also the breaking mechanism of concrete. [4]

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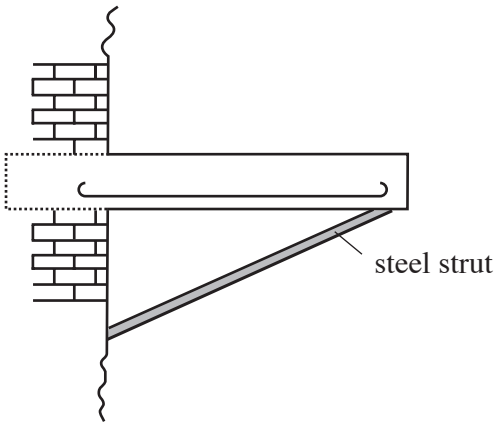
(iii) To increase the support on the balcony the designers fitted steel struts as shown. The reinforcing rod is now moved so that it is nearer the lower surface. Explain this. [1]



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(b) Designers take care to ensure the struts are able to withstand large compressive forces. Each steel strut has a cross-sectional area of $2{\cdot}5 \times 10^{-3}\,m^2$, and is 2·5 m long. Calculate the magnitude of the compressive force, applied along the length of the strut, which will cause it to shorten by 0·50 mm. The Young Modulus for the steel is $200\,GN\,m^{-2}$. [3]

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3. The diffraction grating formula is given below.

$$n\lambda = d \sin\theta$$

(a) State the meaning of

(i) n, [1]

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(ii) d. [1]

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(b) White light containing a spread of wavelengths ranging from 450 nm (violet) to 700 nm (red) is incident normally on a diffraction grating. It is observed that the **first-order violet** line occurs at $\theta = 22°$.

(i) Calculate d. [2]

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(ii) Calculate the angular separation between first order red and first-order violet. [2]

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(c) Show that the second order spectrum for red (700 nm), will **not** be present. [3]

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(d) State what would be seen at $\theta = 0$. [1]

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4. The value of the force of air resistance, F_{drag}, on an object falling at high velocity through the air, is given by the formula

$$F_{drag} = kv^2$$

where k is a constant, and v is the object's velocity.

(a) Show that the units of k can be written as kg m^{-1}. [2]

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(b) A stone of mass 3·0 kg is falling through air at its terminal velocity of $50\ \text{ms}^{-1}$.

(i) Explain in terms of forces why the stone reaches terminal velocity. [1]

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(ii) Calculate k. [Refer to the data on page 2]. [2]

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(c) State the acceleration of the stone when its velocity was 0, at the beginning of the fall. [1]

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(d) Calculate the acceleration of the stone when its velocity is $30\ \text{ms}^{-1}$. [4]

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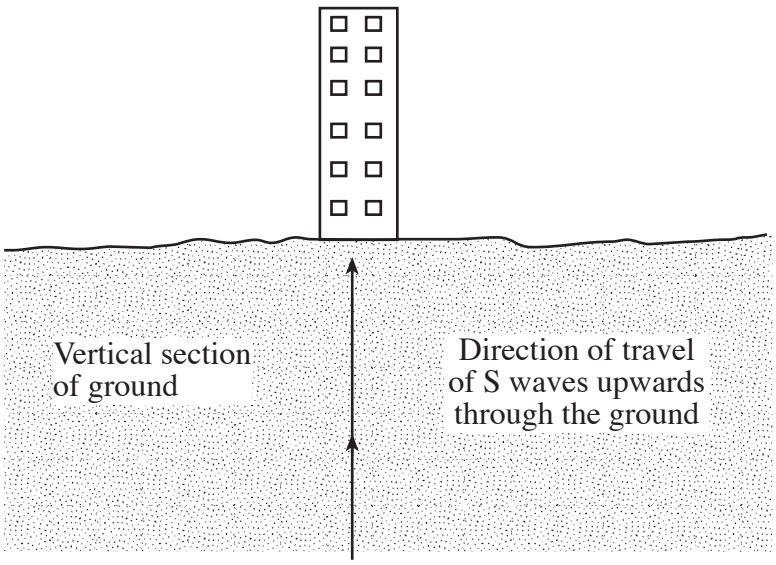
5. This question is about the physics of seismic waves.

When an earthquake occurs two kinds of seismic wave travel from their source through the body of the Earth. Primary or P waves have the greater speed and are *longitudinal*. The slower Secondary or S waves are *transverse*.

(a) The diagram shows a Secondary wave approaching a tall building from underneath. Indicate, with a double-headed arrow, in which direction you would expect the building to vibrate when the wave reaches it. Explain your reasoning.



Explanation: .....

..... [2]

(b) P waves travel with a speed of $7{\cdot}8\,\text{km}\,\text{s}^{-1}$, and S waves with a speed of $5{\cdot}2\,\text{km}\,\text{s}^{-1}$ near the surface. Assume that these speeds are constant for this part of the question. Following a particular earthquake a seismological station observed that P waves were first detected after time **t**, and S waves were detected 58 seconds **later**.

(i) Use the formula speed = distance/time to write an expression for the distance, in km, travelled by the P waves, d_p, from the source to the seismological station. [1]

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(ii) Hence write an expression for the distance travelled by the S waves, d_s, from the source to the seismological station. [1]

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(iii) Given that $d_p = d_s$, calculate the time taken for the P waves to travel from the source to the seismological station. [1]

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(iv) Hence determine the distance from the source to the seismological station. [1]

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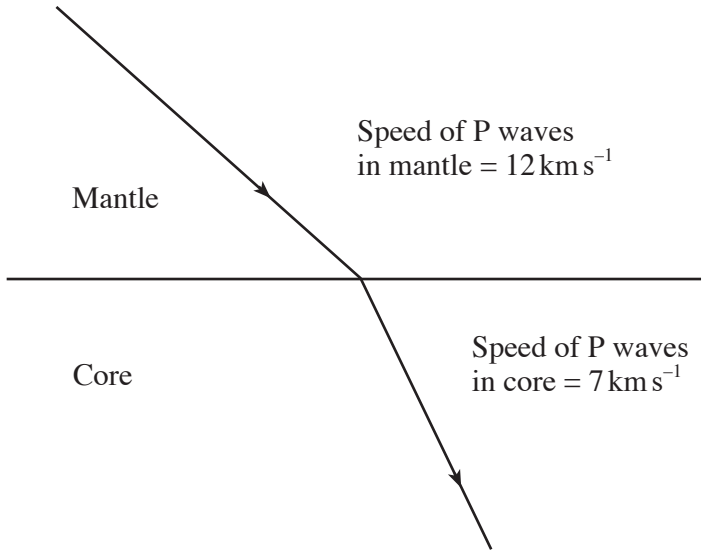
(c) The study of seismic waves provides evidence about the internal structure of the Earth because they are refracted in a similar way to light. The diagram shows how the speed of P waves, now travelling deep inside the Earth, changes as they travel from the mantle to the core.



(i) Use the information given in the diagram to calculate a value for the refractive index of the core with respect to the mantle at the core-mantle boundary. [2]

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(ii) Calculate the critical angle for P waves, which are travelling in the core and are incident at the core-mantle boundary. [2]

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6. *(a)* (i) Explain the term *diffraction*. [2]

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(ii) The diagrams show straight water waves approaching barriers. The gap between the barriers in diagram A is the same size as the wavelength of the approaching waves, whereas in diagram B the gap is much bigger. In both cases, draw on the diagrams **three** diffracted wavefronts, showing their shapes and positions. [3] [2]

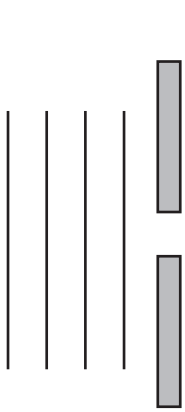

Diagram A

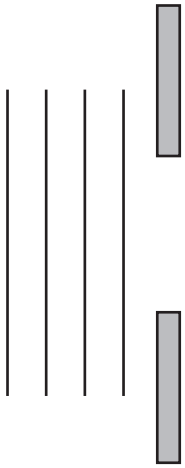

Diagram B

(b) Interference patterns are produced when two wave sources are placed near each other and there is a *constant phase difference* between the sources.

(i) What term is used to describe sources that have a constant phase difference? [1]

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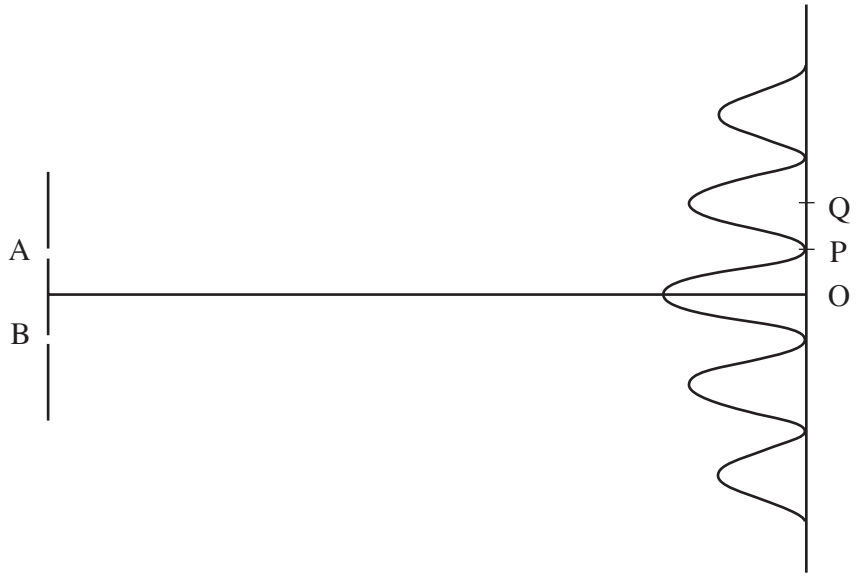
(ii) An interference pattern is produced when light of a single wavelength passes through two narrow slits A and B. The interference pattern may be represented graphically as shown.



Determine the path difference, in wavelengths, between

(I) AO and BO, [1]

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(II) AP and BP, [1]

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(III) AQ and BQ. [1]

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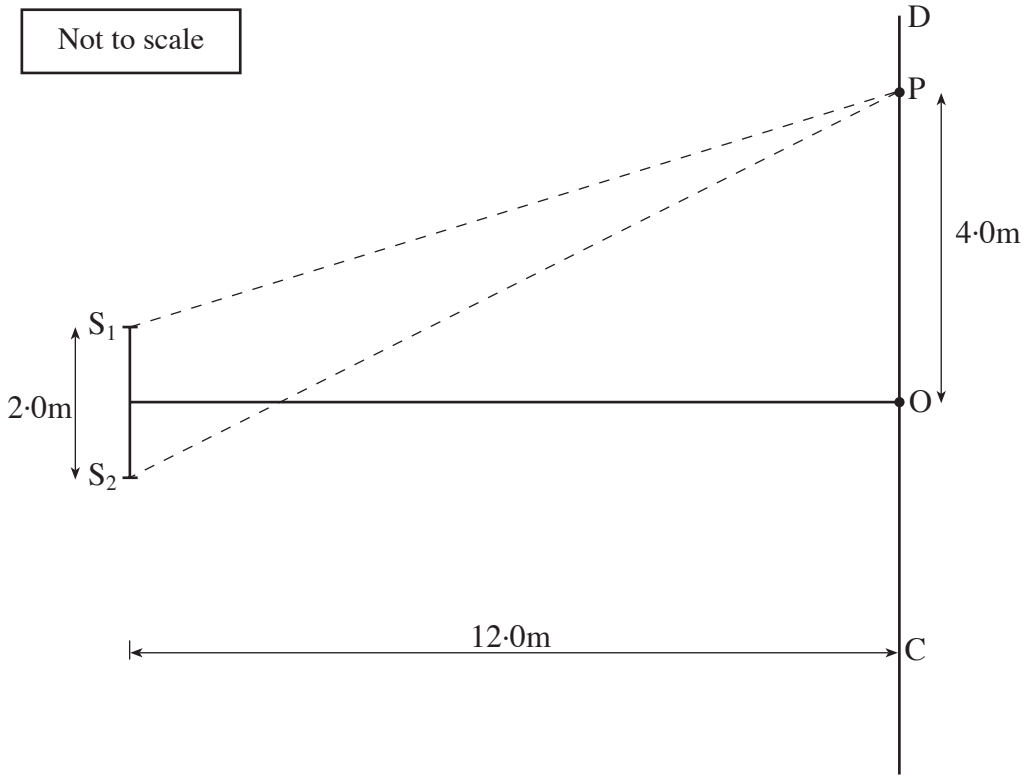
(c) In an experiment to determine the speed of sound, two loudspeakers (S_1 and S_2), connected to the same signal generator, are placed 2·0 m apart in an open field. A listener walks from C to D. The perpendicular distance between the sources and line CD is 12·0 m. As she walks, she hears sound of a **maximum intensity** at O. The first position of **minimum intensity** is at P.



(i) The distance between O and P is 4·0 m. Show clearly that $S_1P = 12{\cdot}4$ m and $S_2P = 13{\cdot}0$ m. [3]

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Turn over.

(ii) Hence find the wavelength of the sound. [2]

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(iii) Calculate the speed of sound given that the frequency of the emitted sound is 280 Hz. [2]

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(d) The student carries out a different experiment with the help of a friend. She asks her friend to bang two pieces of wood together with a frequency of 1 Hz. This produces a regular series of sharp claps. The student now walks away from her friend to the point where she first hears the claps **half way in time between seeing them**.

(i) Using your answer to *(c)*(iii), determine the distance between the students at this point. [1]

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(ii) Write down one other distance where the student would again hear the claps halfway in time between seeing them. [1]

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7. *(a)* State the difference between scalar and vector quantities. [1]

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(b) *Displacement* is a vector quantity. Give **one** other example of a vector quantity. [1]

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(c) A car travels from rest in a straight line for 16 seconds. The displacement-time graph (labelled **Graph A** on the facing page), shows the **first 12 seconds** of the journey.

(i) Using an appropriate equation of motion, calculate the initial acceleration of the car. (i.e from $t = 0{\cdot}0$ to $t = 2{\cdot}0$ s). Assume that this acceleration is constant and that the car starts from rest. [3]

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(ii) Hence calculate the velocity of the car after 2·0 s. [2]

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(d) On **graph B** on the facing page, draw a velocity-time graph for the motion of the car between $t = 0{\cdot}0$ and $t = 12{\cdot}0$ s. Assume the deceleration between $t = 5{\cdot}0$ s and $t = 7{\cdot}0$ s is constant.

The velocity-time graph for $t = 12{\cdot}0$ s to $t = 16{\cdot}0$ s is given. [3]

(e) Using the **velocity-time** graph, determine the distance travelled by the car between $t = 12{\cdot}0$ s and $t = 16{\cdot}0$ s. [2]

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(f) Hence sketch on the **displacement-time graph** the curve from $t = 12{\cdot}0$ s to $t = 16{\cdot}0$ s. [2]

(g) Using **either** the displacement-time graph or the velocity-time graph determine

(i) the distance travelled by the car from $t = 0{\cdot}0$ to $t = 16{\cdot}0$ s [1]

.....

(ii) the displacement of the car at $t = 16{\cdot}0$ s. [1]

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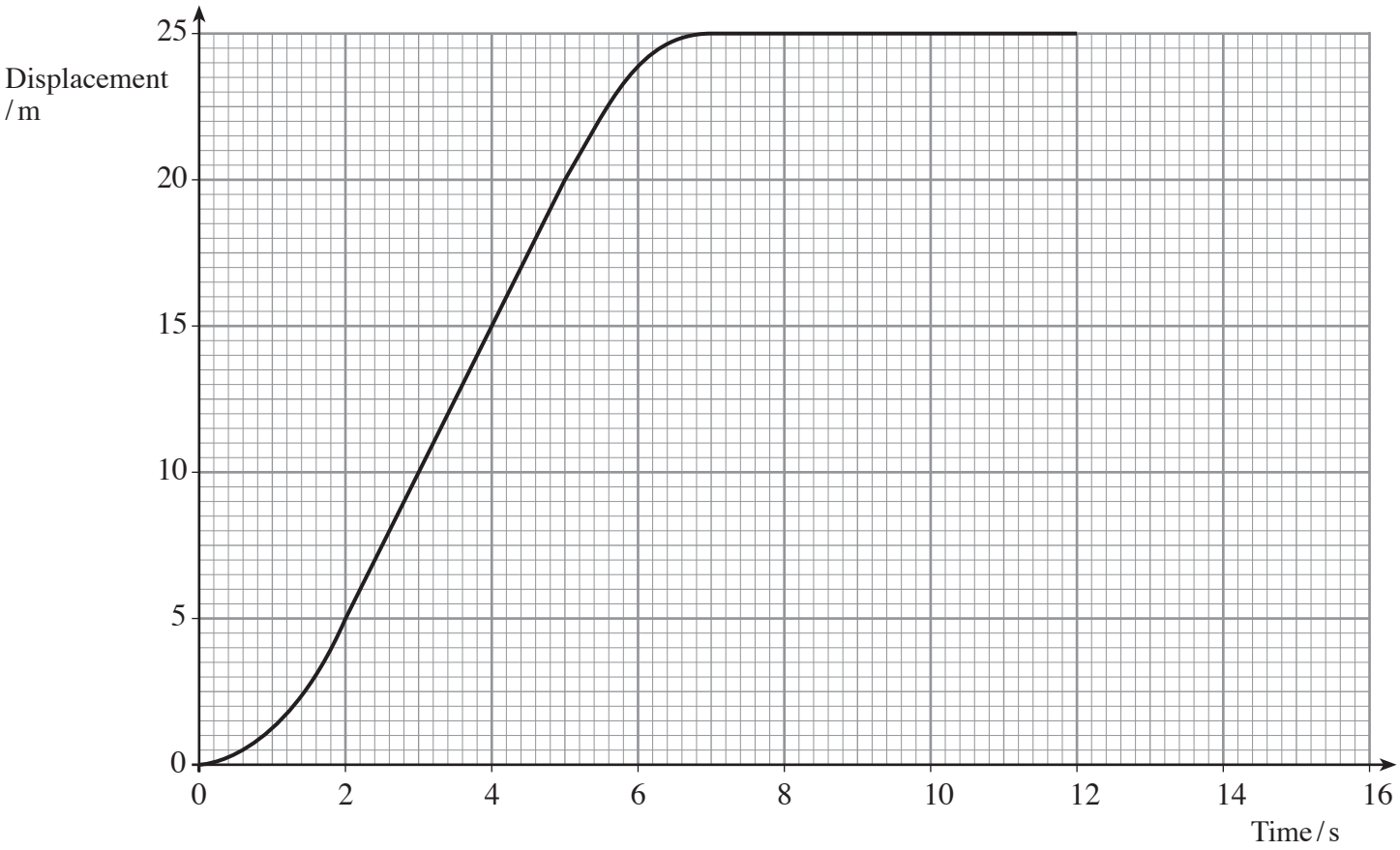
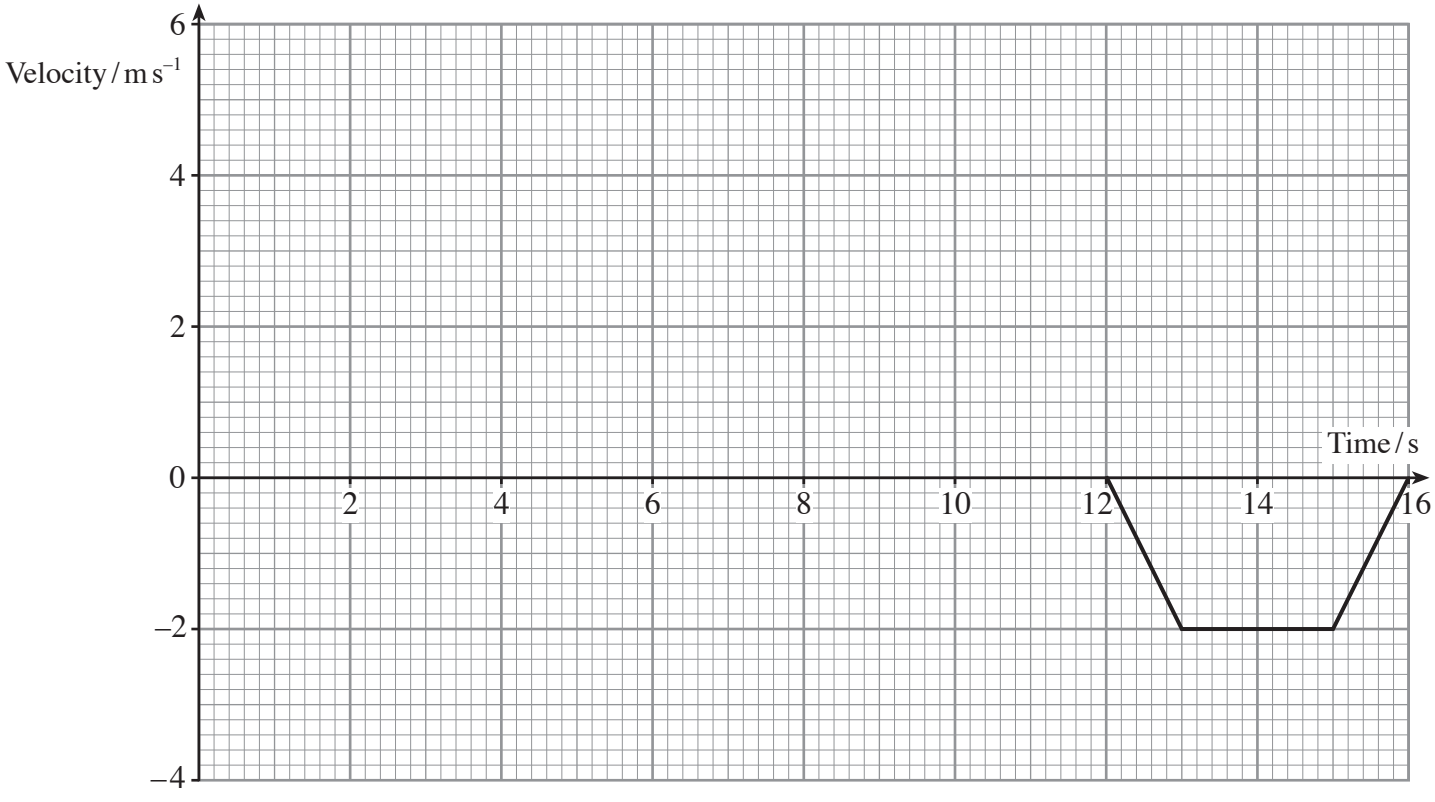
Turn to page 16 for part (h) of this question.

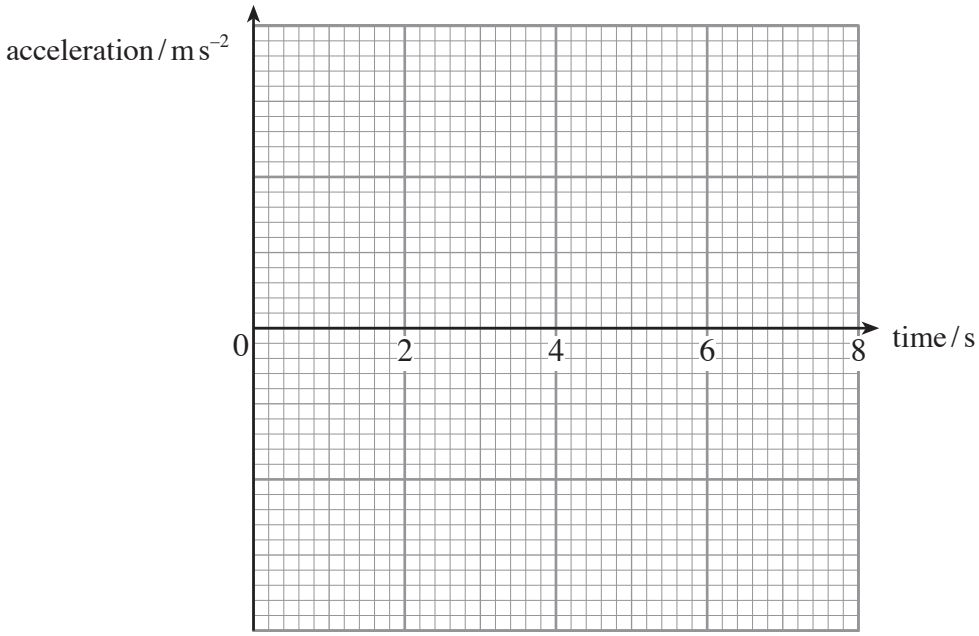


Graph A



Graph B

(h) Using the axes below, draw a graph of acceleration-time for the first 7·0 s of the car's journey. Include a suitable scale on the acceleration axis. Space is provided for your calculations. [4]



Calculations:

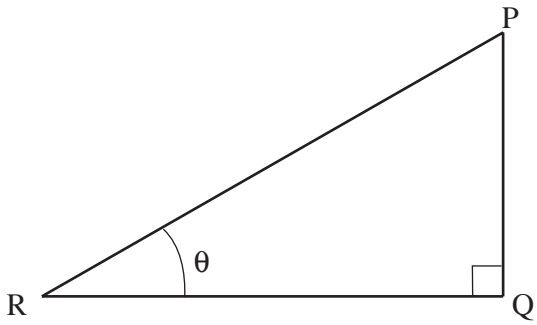
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Geometry and trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

Areas and Volumes

Area of a circle $= \pi r^2 = \frac{\pi d^2}{4}$

Area of a triangle = ½ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$