Candidate Name	Centre Number	Candidate Number

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

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

541/01

PHYSICS

ASSESSMENT UNIT PH1: Waves, Light and Basics

P.M. MONDAY, 14 June 2004

(1 hour 30 minutes)

For Examiner's use only.	
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Total	

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.

TJ*(0032/26)

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
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
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}

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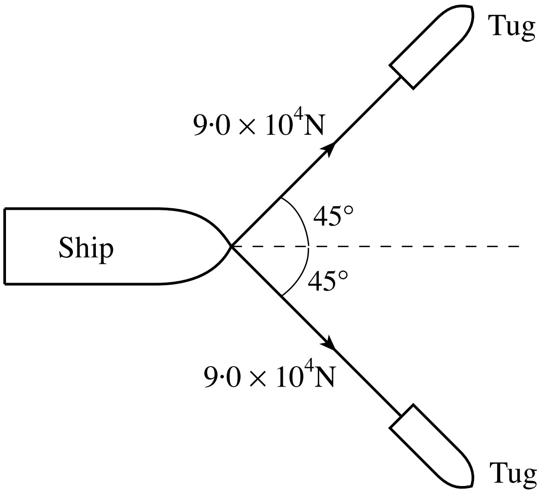
1. A ship is being pulled at a **constant velocity** of 8·0ms^{-1} by two tugs as shown in the diagram.



(a) (i) Calculate the magnitude of the resultant of the forces applied by the tugs. [3]

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(ii) On the diagram, draw an arrow to represent the direction of this resultant force. [1]

(iii) Write down the magnitude of the frictional (drag) force exerted on the ship. [1]

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(b) This ship, which has a mass of 5·0 × 10^{5} kg, is being pulled at the **same** velocity as in part *(a)* when the tow ropes are simultaneously released. Calculate

(i) the ship's initial deceleration, [2]

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(ii) the distance travelled by the ship as it slows to 6·0 ms^{-1}. Assume that the deceleration stays at the value calculated in *(b)*(i). [3]

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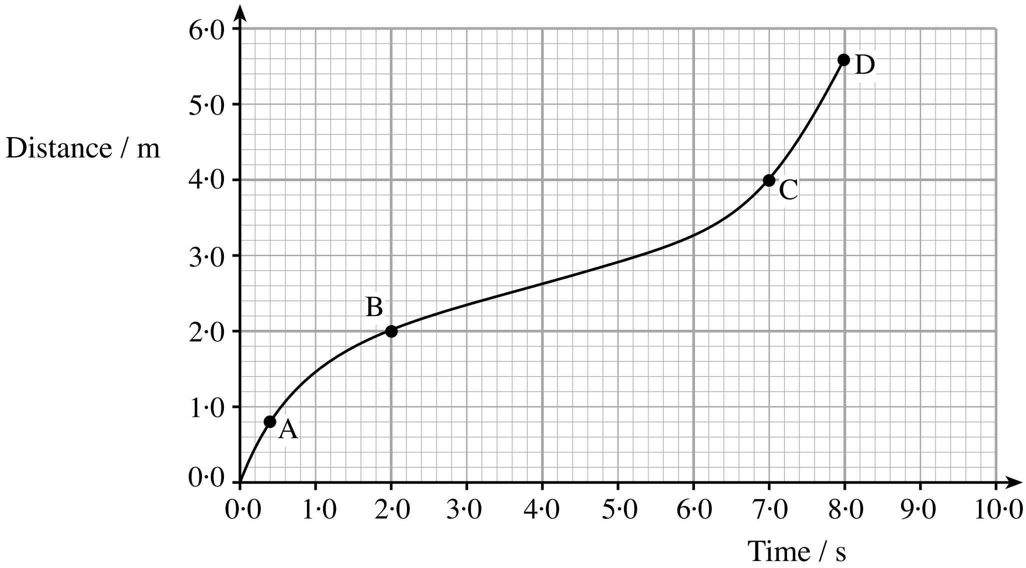
2. A distance-time graph for the motion of a toy train over a period of 8·0 s is given below.



(a) Describe the motion of the train in the region A-B. [1]

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(b) (i) Define *mean speed*. [1]

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(ii) Determine the mean speed of the train between 2·0s and 7·0s (i.e. between points B and C). [2]

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(c) (i) What does the slope of the graph represent? [1]

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(ii) Find the instantaneous speed of the train at t = 6·0 s. [2]

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(d) Mark on the graph, **with the letter L**, one point where the instantaneous speed at that point is less than that calculated in *(c)* (ii). [1]

(e) The curve is very steep between points C and D. Explain, making reference to the motion of the train, whether or not it would be possible for the curve to be completely vertical. [2]

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3. A body is said to be in equilibrium when the following conditions apply:

(i) no resultant force,

(ii) no net moment.

(a) Choose **one** of these conditions and explain its meaning. [2]

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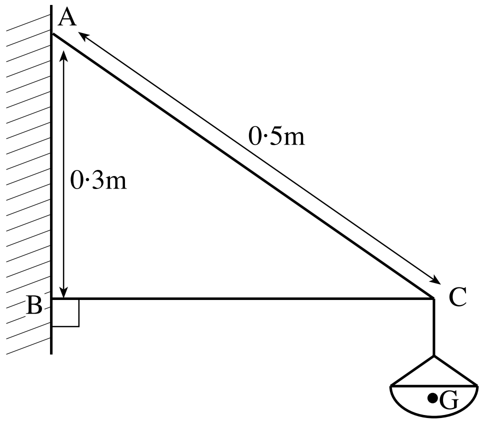
(b) The diagram shows a hanging basket of mass 5·0kg and a bracket attached to a concrete wall. The mass of the bracket is negligible.



(i) The entire weight of the basket can be considered to act at point G. Calculate the pull of gravity on the basket and draw an arrow to show this force on the diagram. (Refer to the list of constants given on page 2). [2]

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(ii) Using a vector diagram, or otherwise, calculate the tension in AC. [4]

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(c) (i) Draw an arrow on the diagram showing the direction of the **force exerted on the wall** by the bar BC. [1]

(ii) Explain your answer. [1]

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Turn over.

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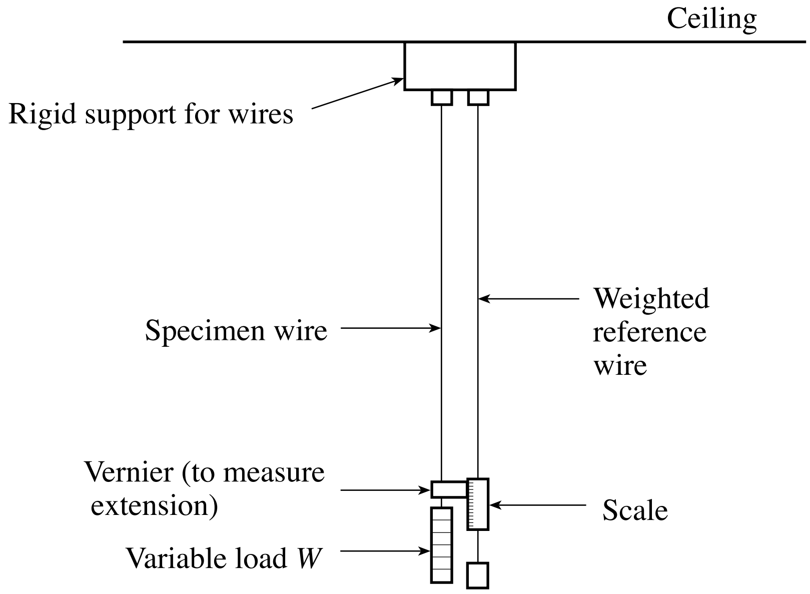
4. The following extract is taken from an A-level textbook. It describes a method for determining the Young modulus of a metal in the form of a wire.

> The apparatus shown in the diagram below can be used to find the Young modulus for a *long specimen wire*. The specimen and a *reference wire* of the same length and material are suspended from a rigid support. This minimises the effect of temperature and the yield of the support.
> Both wires are made taut and free of kinks by suitable weighting and the zero position found for the specimen wire by reading the Vernier. (A Vernier is a device for measuring extension accurately).
>
> 
>
>
> (Diagram not to Scale)
>
> Successive extension readings are taken as the load on the specimen wire is increased but kept within the *elastic limit*. Readings are repeated during removal of the load, to provide mean values of extension. The length of the wire *L* is then found. A mean value for wire diameter *d* is obtained by making two measurements perpendicular to each other, with a micrometer, at a number of places along the wire.
>
> [*Adapted from: "Concise Physics" by: H. Matyka, pages 62 & 63. Copyright (1987)*]

(a) (i) Explain why a *long* wire is used, rather than a short one. [1]

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(ii) Why is it important that both the specimen and reference wires are made from the same material? [1]

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(iii) State two experimental precautions that have been carried out in order to minimise uncertainties when taking measurements. [2]

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(iv) State what is meant by the term *elastic limit*. [1]

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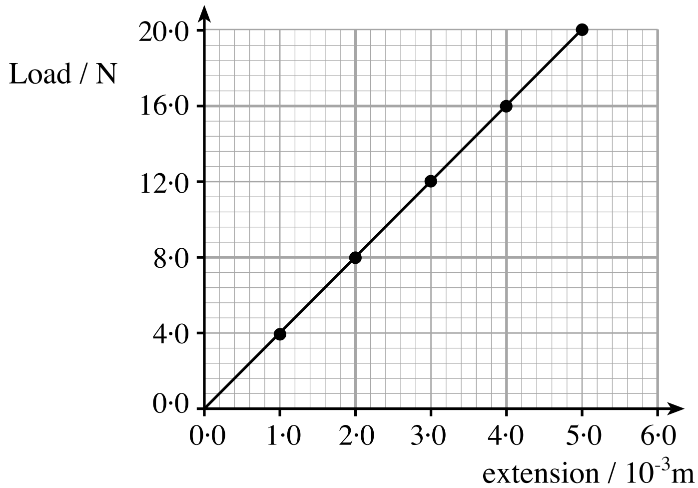
(b) A load against extension graph for the specimen wire is given below. The original length of the wire was found to be 1·80 m and the mean value of its **diameter** was 0·32 mm.



Using the graph and the data given, determine

(i) the cross-sectional area of the specimen, [1]

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(ii) the Young modulus of the material of the specimen. [4]

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5. *(a)* What is a *diffraction grating*? [2]

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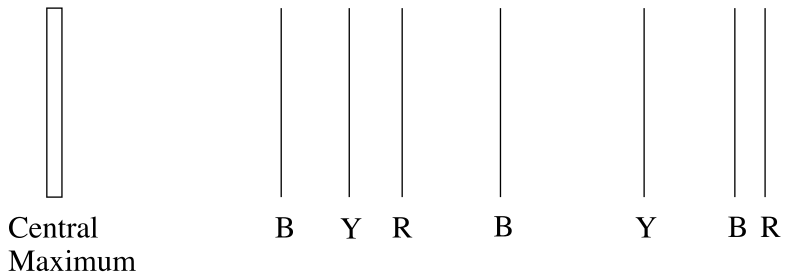
(b) The light emitted by a certain substance consists of three main colours - blue (**B**), yellow (**Y**) and red (**R**), each having a specific wavelength. When the spectrum is examined with a diffraction grating it is found that the sequence of lines on one side of the central maximum is:



(i) Write down the diffraction grating formula and hence explain which of the colours has the longest wavelength. [3]

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(ii) Label with the letter **X** on the above diagram the second order yellow line. [1]

(iii) The pattern of the first 3 lines is **B Y R**. Explain why this pattern is not repeated. [2]

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(iv) The spacing, d, of the grating is $3{\cdot}0 \times 10^{-6}$m. Calculate the wavelength of the blue light, given that the diffraction angle of the **sixth line** in the diagram from the central maximum is 26·7°. [2]

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6. *(a)* An observer sees a farmer hammering in a fencepost. The time interval between each hammer blow is 2·0 s. The observer, who is 660 m away, hears the blows coinciding with the actual blows.

(i) Explain why it is possible for this to occur. [2]

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(ii) Calculate a value for the speed of sound in air. [1]

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(iii) Explain what the observer would see and hear if he walked towards the farmer. [1]

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(iv) Is there any other distance (closer or further away) between farmer and observer where the observer would see and hear the blows again coinciding with each other? Explain your answer. [2]

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(b) A **stationary wave** is set up in a string. A student uses a flashing light to investigate the shape of the string at various intervals. The student varies the frequency of the flashing light until she notices the string alternate between its **extreme** positions as shown in the following two diagrams.

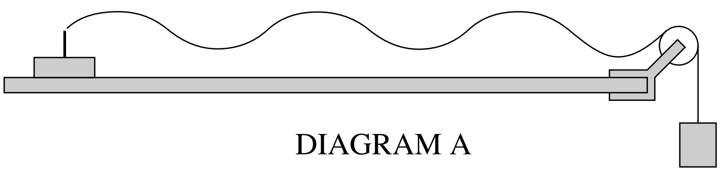

DIAGRAM A

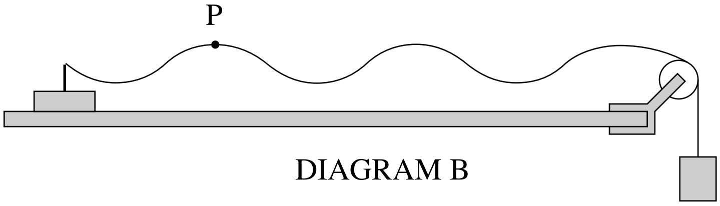

DIAGRAM B

(i) The flashes were 0·1s apart. Calculate **two** possible values for the period of the stationary wave. Explain how you arrive at your answers. [4]

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(ii) Using **one** of your values for period, calculate a possible value for the frequency of vibration of the string. [2]

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(iii) Some positions along the string's length are permanently at rest.

(I) What are these positions called? [1]

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(II) Label clearly on diagram **A** the position of **one point** where the string is permanently at rest. [1]

(iv) The length of the string is 2·0 m. Use this information and your answer to *(b)*(ii) to calculate a possible value for the speed of transverse waves along the string. [4]

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(c) P is a point on the string. On diagram **B**,

(i) label with the letter Q, one point which is in phase with P; [1]

(ii) label with the letter R, one point which is out of phase with P. [1]

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7. This question is about the physics of compact discs (CDs) and compact disc players.

(a) A laser light inside the CD player is *polarised*.

(i) Explain the difference between polarised light and unpolarised light. [3]

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(ii) A polarising filter is placed in front of a polarised light source. Explain what an observer would see as the polarising filter is rotated through 180°. [3]

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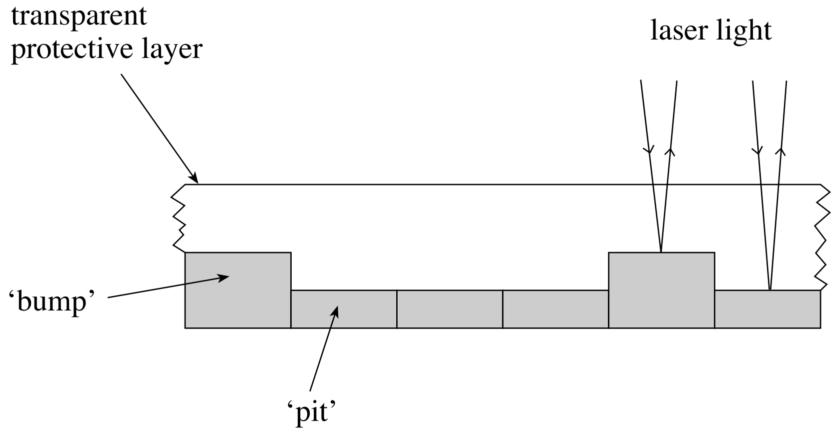
(b) The figure below shows a cross-section through a CD. The metal layer of the CD contains a series of 'pits' and 'bumps'. This is where the information is recorded. The metal layer is then coated with a transparent protective layer made from clear plastic.



The CD is read using red laser light of wavelength 750 nm. The light is reflected from the metal layer and processed at a detector. When the light meets a 'bump' it is reflected and **interferes destructively** with light reflected from a neighbouring 'pit'. (For parts (i) and (ii) of this question, refer to the list of constants given on page 2.)

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(i) Calculate the frequency of the red laser light. [2]

(ii) The transparent protective plastic has a refractive index of 1·50.

(I) Show that the speed of the laser light in the plastic is $2{\cdot}00 \times 10^{8}\ ms^{-1}$. Assume that the refractive index of air = 1·00. [2]

(II) Hence calculate the wavelength of the laser light in the plastic coating. [2]

(iii) The height of the bumps on the CD is 125×10^{-9} m. Use this information and your answer to *(b)*(ii)(II) to explain how destructive interference occurs. [4]

(c) (i) Explain why a speck of dust on the surface of the disc is said to be accelerating, even though it is rotating at constant speed. [3]

(ii) State the direction of the acceleration experienced by the speck. [1]

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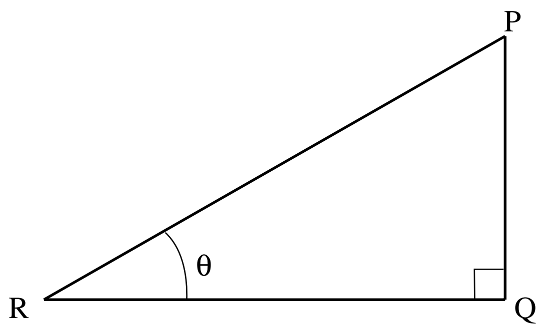
Mathematical Data and Relationships

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	$4\pi r^2$	$\frac{4}{3}\pi r^3$