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

A.M. FRIDAY, 8 June 2007

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this examination 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.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
Total	

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 table of "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.

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}\ \text{mol}^{-1}$
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	=	$8{\cdot}3\ \text{J mol}^{-1}\ \text{K}^{-1}$
Acceleration due to gravity at sea level	g	=	$9{\cdot}8\ \text{m s}^{-2}$
[Gravitational field strength at sea level	g	=	$9{\cdot}8\ \text{N kg}^{-1}$]
Universal constant of gravitation	G	=	$6{\cdot}7 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}\ \text{J K}^{-1}$
Unified mass unit	1 u	=	$1{\cdot}66 \times 10^{-27}$ kg
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^{8}\ \text{m s}^{-1}$
Permittivity of free space	ε_o	=	$8{\cdot}9 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}\ \text{H m}^{-1}$

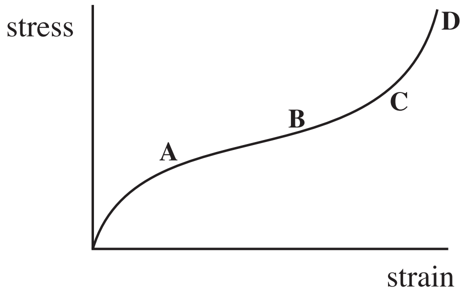
Examiner only
Arholwr yn unig

1. *(a)* Rubber is a *polymer*. Explain the term polymer. [1]

....

....

(b) A stress-strain graph for rubber is shown below.



Explain, in terms of molecules,

(i) why the curve in the region AB is not very steep, [2]

....

....

....

(ii) why the curve in the region CD is much steeper. [2]

....

....

....

(c) (i) Define the Young modulus. [1]

....

(ii) Explain, in terms of this definition, why the Young modulus for rubber is low compared with steel. [2]

....

....

....

(d) Car tyres are a composite of rubber and steel.

(i) Give one property of rubber that makes it suitable for use in car tyres. [1]

....

(ii) Give one property of steel that makes it suitable for use in car tyres. [1]

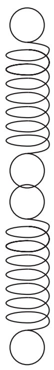
....

Turn over.

2. *(a)* Define the spring constant, *k*. [1]

....

(b) The diagram shows two identical light springs, **each** with a spring constant, *k*, of 24 Nm^{-1}, connected together in series. Determine the overall spring constant for the spring system. Explain your answer. [3]



....

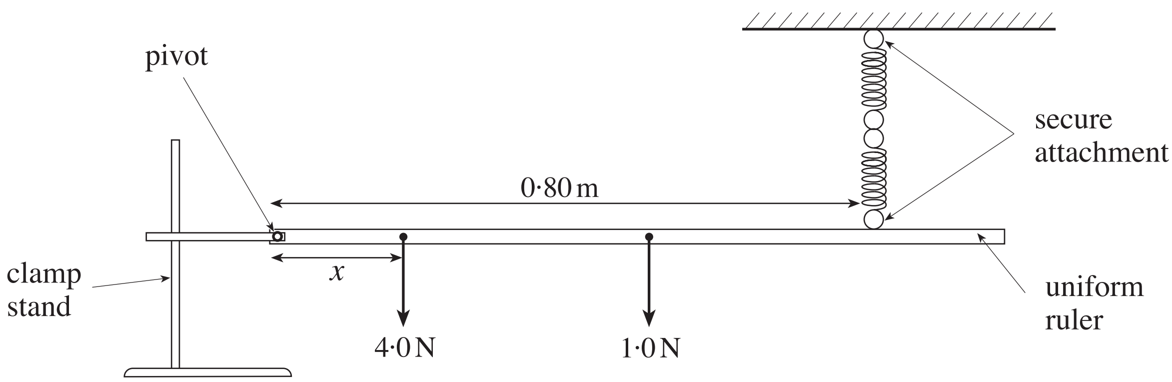
....

....

....

....

(c) The following apparatus is set up to investigate moments using the same springs as in *(b)*. A uniform 1·0 m ruler weighing 1·0 N is pivoted at one end. A 4·0 N weight is suspended from the ruler at a distance *x* from the pivot in order to make the ruler horizontal.



(i) Using your answer to *(b)* and the following data, determine the tension in the springs when the ruler is horizontal.

Unstretched length of **each** spring = 4·0 cm.

Stretched length of **both** springs when the ruler is horizontal = 18·0 cm. [3]

....

....

....

(ii) Hence calculate *x*. [3]

....

....

....

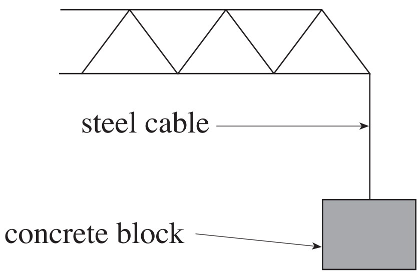
3. *(a)* Newton's second law of motion is sometimes written as $\Sigma F = ma$.
Explain the term ΣF, giving an example to illustrate your answer. [2]

....

....

....

(b) A crane has a maximum safe working load of 12 000 N. It is used to lift a concrete block of mass 1000 kg.



(i) Determine the tension in the cable when the block is lifted at constant speed. [Refer to the data on page 2]. [1]

....

....

(ii) Calculate the maximum safe upward acceleration of the block. [3]

....

....

....

(c) The cable has a cross-sectional area of $1{\cdot}2 \times 10^{-3}\,\text{m}^2$ and is made from steel, which has a Young modulus of $2{\cdot}0 \times 10^{11}\,\text{Nm}^{-2}$. As the concrete block moves upwards the tension in the cable changes depending on whether the block is accelerating, decelerating or moving at constant speed. At one point in its motion the strain of the cable is $3{\cdot}75 \times 10^{-5}$.

(i) Calculate the tension in the cable that produces this strain. [3]

....

....

....

....

(ii) Hence state whether the block is accelerating, decelerating or moving at constant speed at this point. Explain your reasoning. [1]

....

....

Examiner only
Arholwr yn unig

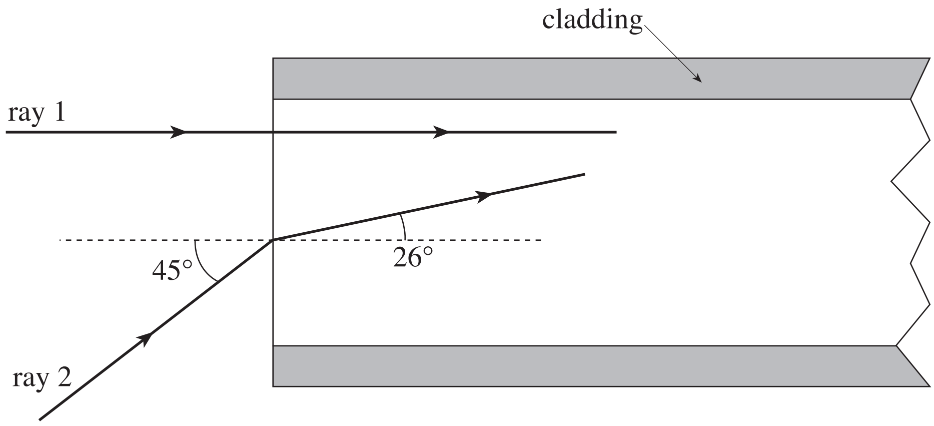
4. *(a)* State Snell's law of refraction. [2]

....

....

....

(b) The diagram shows two light rays entering an optical fibre.



(i) Use the information in the diagram to calculate the refractive index of the optical fibre. [2]

....

....

(ii) Suggest, giving a reason for your answer, a suitable range for the refractive index of the cladding. [2]

....

....

....

(iii) Determine the time taken for **ray 1** to travel 10 km along the length of this optical fibre. [Refer to the data on page 2]. [2]

....

....

(c) Give two advantages of using optical fibres rather than copper wires for transmitting information. [2]

....

....

....

....

Examiner only
Arholwr yn unig

5. *(a)* Sound is a *longitudinal* wave. Explain the term longitudinal. [1]

....

(b) The speed of sound waves *(v)* in a metal rod can be given by the equation

$$v^2 = \frac{E}{\rho}$$

where E is the Young modulus of the metal and ρ is the density of the metal.

(i) Use the equation to find the speed of sound in a steel rod with Young modulus $2{\cdot}1 \times 10^{11}\,\mathrm{Nm^{-2}}$ and density $7800\,\mathrm{kg\,m^{-3}}$. [1]

....

....

(ii) Show that the equation is correct in terms of units (or dimensions). [4]

....

....

....

....

....

(iii) Two students stand a distance d apart beside a long steel rail on a still day. One student places his ear against the rail while the other gives the rail a sharp knock with a hammer. The first student hears two sounds, first the sound that travelled through the steel rail and, 0·40s later, the sound that travelled through the air. Using your answer to *(b)*(i), and given that the speed of sound in air is $330\,\mathrm{ms^{-1}}$, calculate d. [4]

....

....

....

....

....

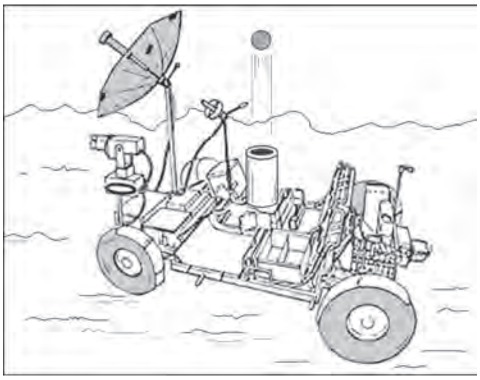
....

6. *(a)* Distinguish between *speed* and *velocity*. [2]

....

....

(b) A NASA Moon vehicle is being used to determine an accurate value for the acceleration due to gravity on the Moon. The vehicle is remotely controlled and positioned so that it is stationary and on level ground. A projectile is fired vertically upwards from the deck of the vehicle and it reaches a height of 3·6 m before landing back on the vehicle. The time of flight is 4·26 s. Note: There is no atmosphere on the Moon.



(i) Show that the initial vertical velocity of the projectile is 3·4 ms^{-1}. [3]

....

....

....

....

....

....

....

(ii) Hence or otherwise determine the acceleration due to gravity on the Moon. [3]

....

....

....

....

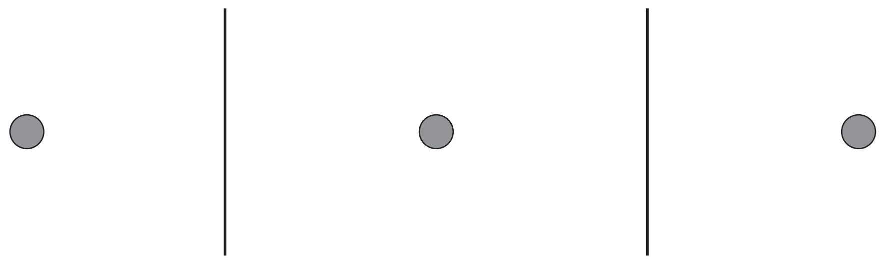
....

(iii) The time taken for the projectile to reach a height of 2·4 m is 0·90 s. Write down one other time when the projectile is at this height. [2]

....

....

(iv) In the spaces provided draw three free-body diagrams showing the force(s) acting on the projectile, at both times when it is at a height of 2·4 m above the vehicle, and also when it has reached its maximum height of 3·6 m. Label the forces. [3]



1st time at 2·4 m | at 3·6 m | 2nd time at 2·4 m

(v) Explain whether or not this would be a valid method of determining the acceleration due to gravity on the **Earth**. [2]

(c) The Moon vehicle is now made to travel in a straight line along the horizontal surface at constant speed of 2·0 ms^{-1}, when the projectile is again fired with a vertical speed of 3·4 ms^{-1}.

(i) Calculate the resultant initial **velocity** of the projectile. [3]

(ii) State whether the projectile will land behind, in front of or on the moving Moon vehicle. Explain your answer in terms of the forces acting on the projectile. [2]

7. *(a)* A Physics text book gives the following definition for stationary waves.

Stationary waves are oscillations that are formed when progressive waves of the same amplitude and frequency, moving in opposite directions, superpose.

(i) Explain the term amplitude. [1]

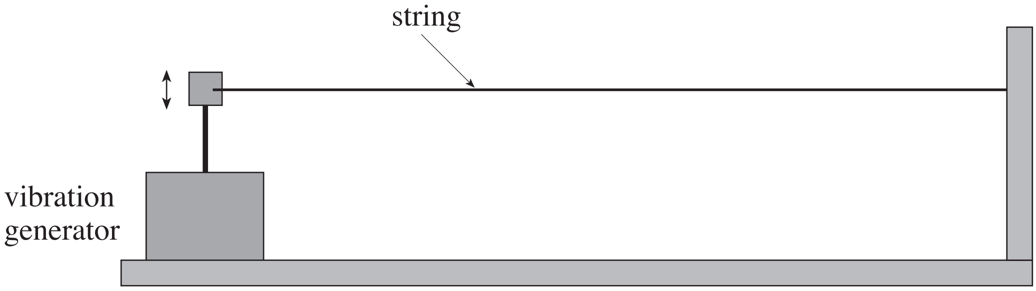
....

(ii) Explain the term superpose. [1]

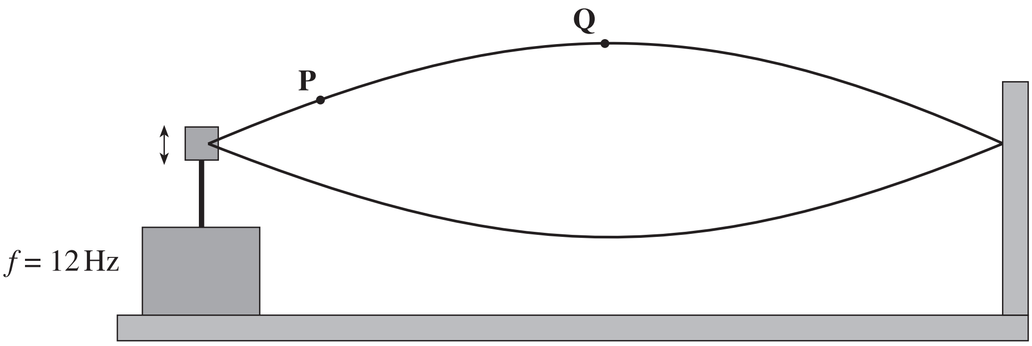
....

....

(b) A student sets up the following apparatus to investigate stationary waves on a string of **length 1·8 m**.



The student notices that, as the frequency of the vibration generator is steadily increased, stationary waves are produced only at certain well-defined frequencies. The first stationary wave to be seen (below) has one loop and occurs at a **frequency of 12 Hz**. **P** and **Q** are two points on the string.



(i) Compare the motion of points **P** and **Q**, paying attention to direction of motion, amplitude and phase. [3]

.....

.....

.....

.....

(ii) Show that the wavelength of this stationary wave is 3·6 m. [1]

.....

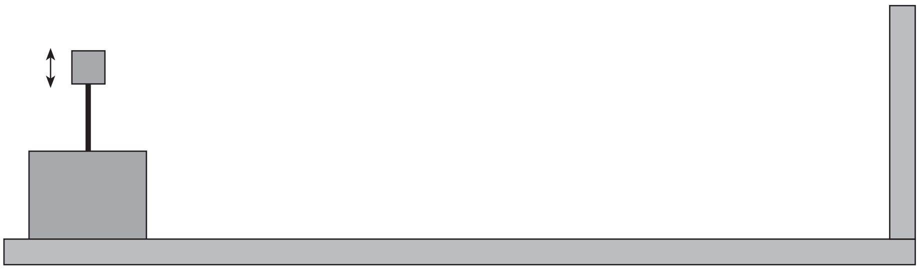
(iii) Calculate the speed of the waves travelling along the string. [2]

.....

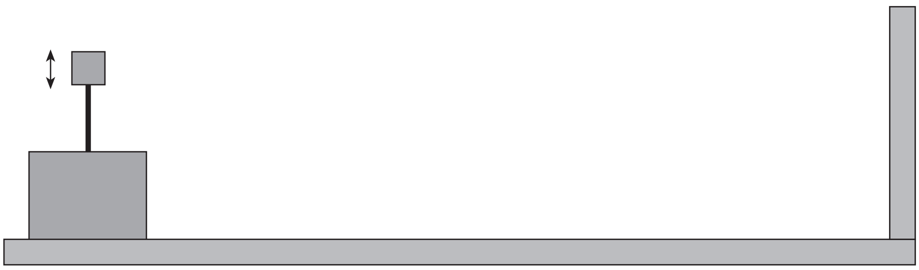
.....

(c) (i) The second stationary wave pattern seen has 2 loops and occurs at a frequency of 24 Hz. The third pattern has three loops and occurs at 36 Hz.
Sketch these patterns on the diagrams below. [3]

$f = 24$ Hz



$f = 36$ Hz



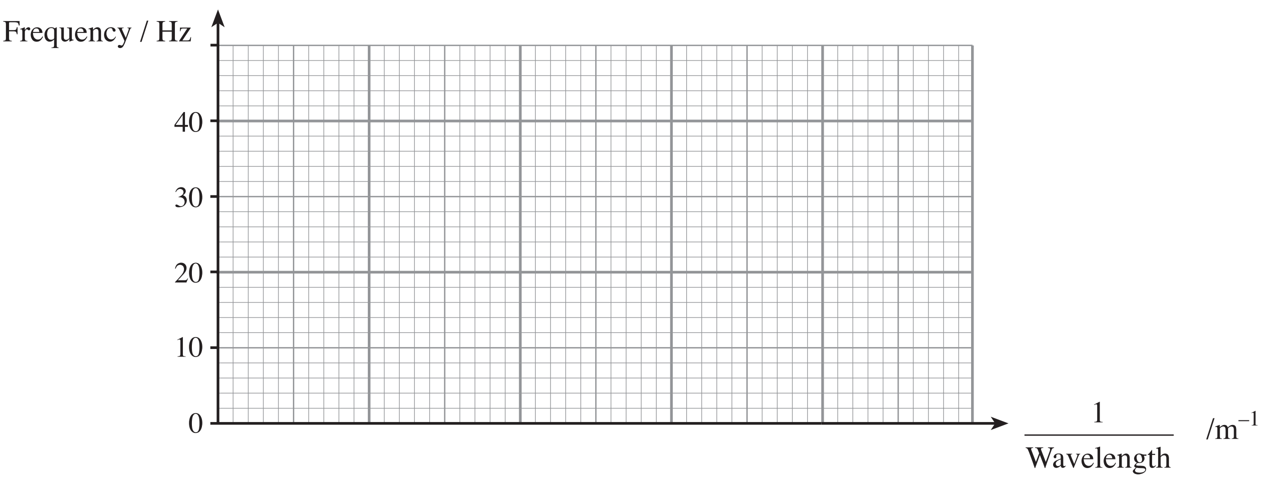
Turn over.

Examiner only
Arholwr yn unig

(ii) Complete the following table. Space is provided for your calculations. [5]

Frequency / Hz	12	24	36
Number of loops	1	2	3
Wavelength /m	3·6		
$\frac{1}{\text{Wavelength}}$ /m^{-1}			
Speed of waves / ms^{-1}			

(iii) Complete the graph of frequency against $\frac{1}{\text{Wavelength}}$. The frequency axis has been inserted for you. [1]



(iv) Using your graph, state the relationship between frequency and wavelength. [1]

....

(v) Calculate the gradient of your graph. What does this gradient represent? [2]

....

....

....

Examiner only
Arholwr yn unig

Examiner only
Arholwr yn unig

Examiner only
Arholwr yn unig

Examiner only
Arholwr yn unig

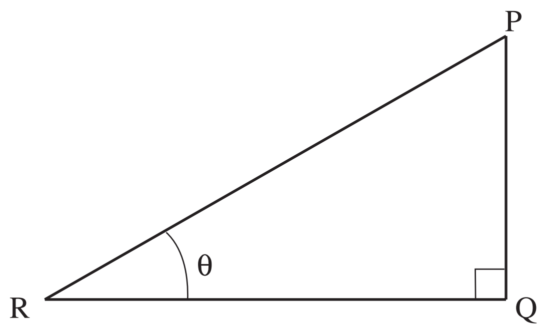
Mathematical Data and Relationships

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 $= \pi r^2 = \dfrac{\pi d^2}{4}$

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