Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

544/01

PHYSICS

ASSESSMENT UNIT PH4: OSCILLATIONS AND ENERGY

A.M. THURSDAY, 14 June 2007

(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.

For Examiner's use only.	
1	
2	
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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.

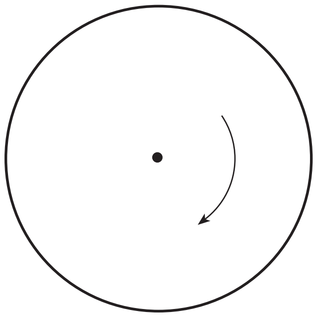
Your attention is drawn to the table of "Mathematical Data and Relationships" on the back page of this paper.

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

Fundamental Constants

Avogadro constant	N_A	=	$6 \cdot 0 \times 10^{23}$ 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 disc in a DVD player is rotating in a horizontal plane at a rate of 11·0 revolutions per second.

(a) Calculate its angular velocity. [2]

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(b) The radius of the disc is 0·060 m. For a point on the edge of the disc,

(i) calculate the speed, [2]

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(ii) and show that the centripetal acceleration is approximately $290\,\text{ms}^{-2}$. [2]

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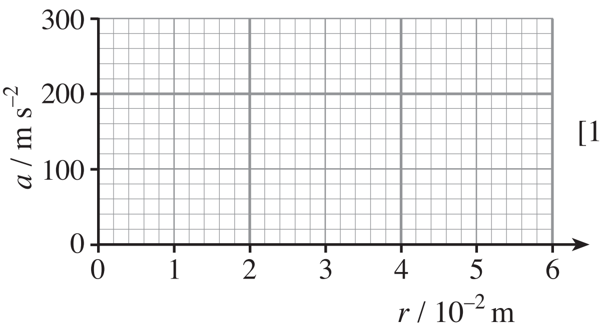
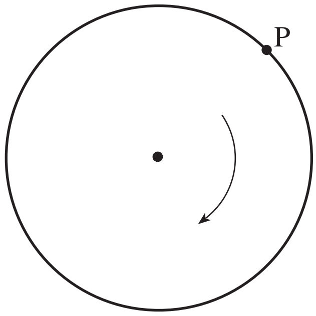
(c) On the grid provided, sketch a graph of *a* against *r*, in which *a* is the centripetal acceleration of a point a distance *r* from the centre of the disc. [1]



(d) A speck of dust of mass $2{\cdot}0 \times 10^{-12}$ kg is stuck to the edge of the disc, at point P.



(i) Calculate the centripetal force on the speck. [1]

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(ii) Show the direction of this force by an arrow, labelled 'A' on the diagram. [1]

(iii) The speck now becomes detached. Show the direction in which it moves immediately afterwards, as an arrow, labelled 'B'. [1]

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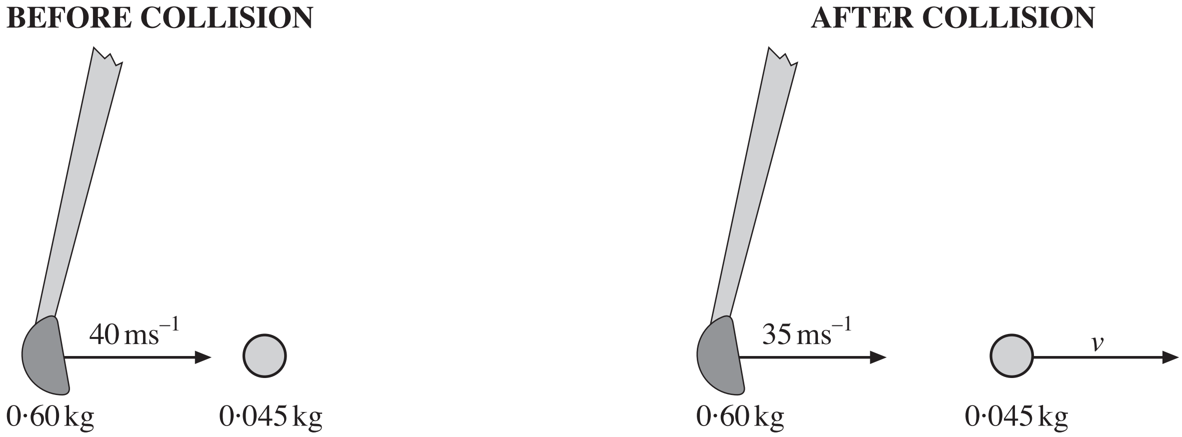
2. A golfer swings his club so that its metal club-head (mass 0·60 kg) strikes a stationary ball (mass 0·045 kg). The velocity of the club-head drops from 40 ms^{-1} to 35 ms^{-1} during the collision. Assume that all velocities are horizontal, as shown in the diagram.



(a) (i) Apply the *Principle of Conservation of Momentum* to find a value for the velocity of the ball after the collision. [2]

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(ii) Give **one** reason why the Principle of Conservation of Momentum is not *strictly* applicable to this collision between ball and club-head. [2]

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(b) Show clearly whether or not kinetic energy is lost in this collision. [3]

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(c) The ball and club-head are in contact for $1{\cdot}5 \times 10^{-3}$ s. Naming the law of Physics that you use, calculate the mean force exerted by the club-head on the ball. [3]

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3. An uncharged 3·0 μF capacitor and an uncharged 6·0 μF capacitor are connected in series.

(a) Calculate the capacitance of the combination. [2]

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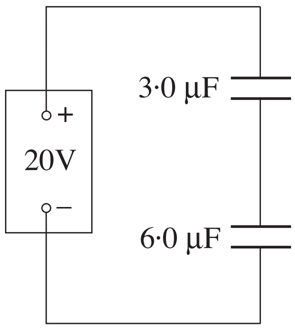
(b)



A power supply of e.m.f. 20V is then connected as shown.

(i) Calculate the charge which flows. [1]

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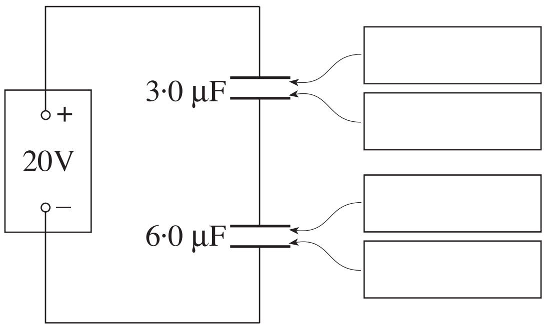

(ii) Write down the final charges on each of the capacitor plates in the boxes on the diagram.

Show the signs of the charges using '+' and '–'. [2]

(c) (i) Calculate the p.d.s across

(I) the 3·0 μF capacitor, [1]

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(II) the 6·0 μF capacitor. [1]

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(ii) Show clearly which capacitor stores more energy. [3]

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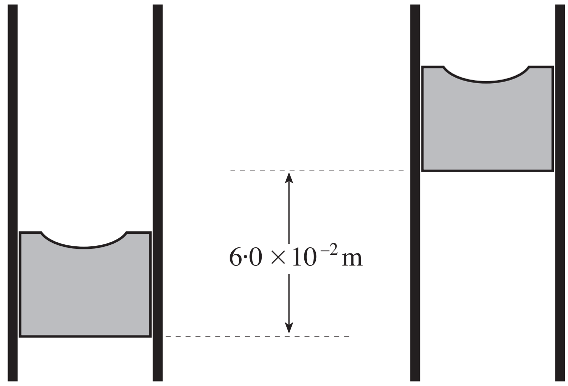
Turn over.

4. When a car engine is running at 2500 revolutions per minute, the pistons in the engine's cylinders are moving up and down at 2500 cycles per **minute**.

The upward displacement, x, of a piston from its mid-position is given (approximately) by the equation

$$x = A \sin \omega t$$

[The piston is in its mid-position, and travelling upwards, at time $t = 0$.]



(a) (i) Calculate the *periodic time*, in seconds, of the piston's motion. [2]

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(ii) Calculate A from the information in the diagram. [1]

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(b) The piston's mass is 1·2 kg. Calculate the maximum (resultant) *force* on the piston. [3]

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(c) (i) Calculate the displacement, x, of the piston when $t = 0{\cdot}0020$ s. [2]

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(ii) Calculate t when the piston **next** passes through this position. [A diagram or sketch-graph of x against t may help you.] [2]

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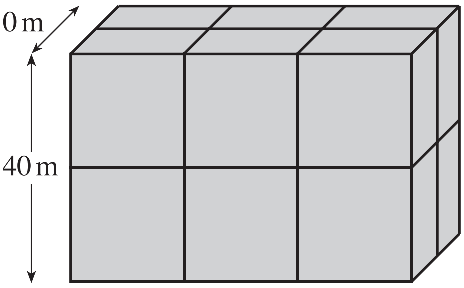
5. An electric storage heater consists of a 2·1 kW heating 'element' embedded in special bricks. The bricks form a block, as shown. The block is covered with a layer of thermal insulation (not shown).



(a) For 7 hours during the night (when electrical energy can be bought more cheaply) the heating element is turned on, to warm up the bricks. 20% of the energy supplied escapes through the insulation during this time. Calculate the rise in temperature of the bricks, if their total mass is 84 kg, and their specific heat capacity is 1800 J kg^{-1}K^{-1}. [4]

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(b) We can apply to the insulation around the block the equation

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta \theta}{\Delta x} \ .$$

(i) (I) Use the data in the diagram to estimate *A*. [2]

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(II) Give one reason why this is only an estimate. [1]

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(ii) Calculate the approximate thickness of insulation needed for heat to escape into the room at a rate of 600 W at a time of day when the bricks are at a temperature of 200°C and the outside of the insulation is at 60°C. [Thermal conductivity of the insulation = 0·28 WK^{-1}m^{-1}.] [3]

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6. A signal generator is set to produce a 50 Hz sinusoidal p.d. of peak value 17·0 V.

(a) (i) Show that the r.m.s. p.d. is 12·0 V. [1]

(ii) Calculate the power dissipated when the p.d. is applied across a 2000 Ω resistor. [1]

(iii) (I) Using digital equipment, the alternating p.d. is 'sampled' at five equally-spaced times over one cycle. The following p.d.s are found:

8·50 V, 16·63 V, 1·78 V, –15·53 V, –11·38 V

Calculate the root mean square (r.m.s.) value of these p.d.s. Show your working clearly. [3]

(II) Comment on your answers to *(a)*(i) and *(a)*(iii)(I). [1]

(b) The same alternating p.d. is now connected across a 2·0 μF capacitor.

(i) Calculate the *reactance* of the capacitor. [2]

(ii) Calculate the r.m.s. current. [2]

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(c) The same alternating p.d. is now connected across a 2·0 μF capacitor in series with a 2000 Ω resistor.

(i) Calculate the *impedance* of the resistor-capacitor combination. [2]

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(ii) Calculate the new r.m.s. current. [1]

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(iii) Calculate the power dissipation. [2]

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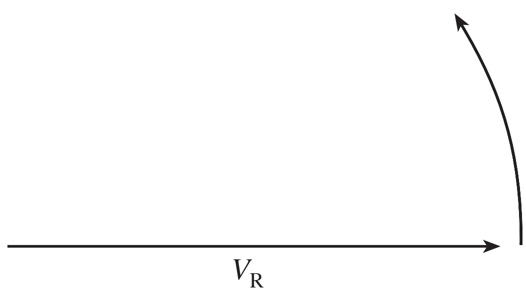
(iv) Complete the diagram by adding the phasors for the p.d.s. across the capacitor and across the resistor-capacitor combination. [Scale drawing is not needed.] [3]



(d) An inductor is now added to the circuit, in series with the resistor and capacitor. The value of the inductor is such that there is resonance at 50 Hz. Write down the value of the r.m.s. current, giving a reason for your answer. [2]

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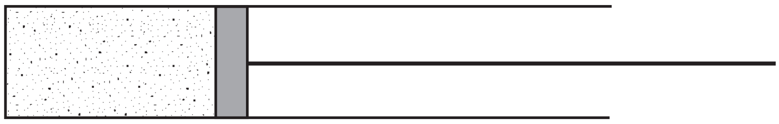
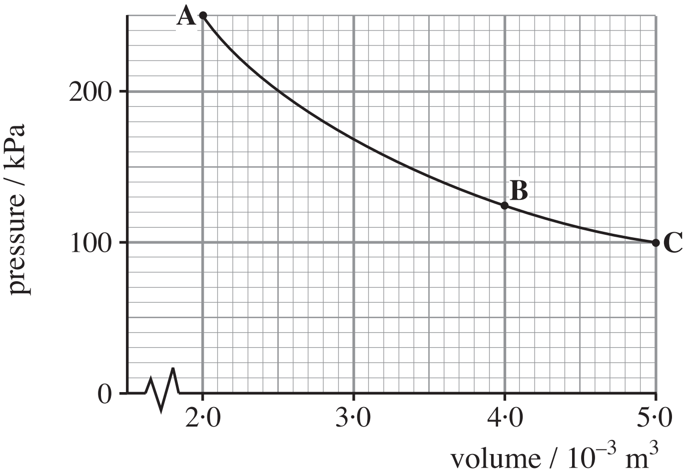


Oxygen gas at a temperature of 300 K is contained in a metal cylinder fitted with a leak-proof piston. The piston is allowed to move slowly from left to right. The gas temperature stays at 300 K throughout. A graph of pressure against volume for the gas is given.



(a) (i) State *Boyle's Law*. [2]

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(ii) Verify that the gas in the cylinder obeys Boyle's Law, using points **A**, **B**, and **C**. [3]

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(b) (i) Use point **A** to calculate the number of moles of oxygen in the cylinder. [2]

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(ii) The relative molecular mass of oxygen is 32. Calculate the *mass* of oxygen in the cylinder. [2]

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(iii) Calculate the r.m.s. speed of the oxygen molecules. [3]

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(c) (i) The *internal energy* of the gas (assumed ideal) does not change as the gas expands. Why is this? [1]

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(ii) The gas does 458 J of work on the piston during the expansion **ABC**.

(I) How, briefly, would you confirm this from the graph? [**You are not required to calculate it.**] [1]

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(II) Does *heat* flow in or out of the gas? Give a reason for your answer. [2]

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(III) How *much* heat flows? [1]

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(d) With the gas initially in state **C**, the pressure is made to increase **at constant volume** until it has reached 250 kPa.

(i) How, in practice, could this increase in pressure be brought about? [1]

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(ii) For this constant volume change, comment without calculation on the values of the quantities Q, ΔU, and W in the equation

$$Q = \Delta U + W$$ [2]

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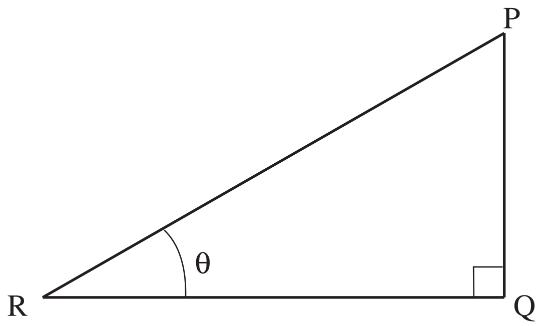
Mathematical Data and Relationships

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

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

Logarithms

[Unless otherwise specified 'log' can be $\log_e$ (i.e. ln) or $\log_{10}$.]

$\log(ab) = \log a + \log b$

$\log\left(\frac{a}{b}\right) = \log a - \log b$

$\log(x^n) = n\log x$

$\log(kx^n) = \log k + n\log x$

$\log_e(e^{kx}) = \ln(e^{kx}) = kx$

$\log_e 2 = \ln 2 = 0{\cdot}693$