Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Physics

International Advanced Level

Unit 5: Thermodynamics, Radiation, Oscillations and Cosmology

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 45 minutes

Paper Reference **WPH15/01**

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL questions.

For questions 1–10, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The gravitational field strength at the surface of the Earth is $9.81\,\text{N kg}^{-1}$. A satellite is orbiting at a height above the ground equal to the radius of the Earth.

What is the gravitational field strength at this height?

☒ **A** $0.00\,\text{N kg}^{-1}$

☒ **B** $2.45\,\text{N kg}^{-1}$

☒ **C** $4.91\,\text{N kg}^{-1}$

☒ **D** $9.81\,\text{N kg}^{-1}$

(Total for Question 1 = 1 mark)

2 A sealed gas jar contains a mixture of different gases. At a given temperature, the mean kinetic energy of the molecules of each gas

☒ **A** depends on how much of each gas is present.

☒ **B** is greater for the gas with less massive molecules.

☒ **C** is greater for the gas with more massive molecules.

☒ **D** is the same for each gas in the mixture.

(Total for Question 2 = 1 mark)

3 When energy is supplied to a substance, changes in the average molecular kinetic energy E_k and the average molecular potential energy E_p can occur.

Select the row in the table which correctly identifies the changes in E_k and E_p when energy is supplied to an ideal gas.

	E_k	E_p
☒ **A**	increase	increase
☒ **B**	increase	no change
☒ **C**	no change	increase
☒ **D**	increase	decrease

(Total for Question 3 = 1 mark)

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4 Which of the following is the reason why the ultimate fate of the Universe is uncertain?

☒ **A** Atmospheric absorption limits our observations.

☒ **B** Our galaxy is not typical of other galaxies in the Universe.

☒ **C** The total average density of the Universe is uncertain.

☒ **D** We cannot observe very distant galaxies.

(Total for Question 4 = 1 mark)

5 When a driver force causes a system to oscillate, the system always

☒ **A** exhibits resonance.

☒ **B** experiences a large increase in amplitude.

☒ **C** oscillates at its natural frequency.

☒ **D** oscillates at the driver frequency.

(Total for Question 5 = 1 mark)

6 A standard candle is a distance x from the Earth. The intensity of the radiation at the surface of the Earth is I.

A second standard candle of the same luminosity is observed. The intensity of the radiation at the surface of the Earth is $4I$.

Which of the following is the distance of the second standard candle from the Earth?

☒ **A** $4x$

☒ **B** $2x$

☒ **C** $x/2$

☒ **D** $x/4$

(Total for Question 6 = 1 mark)

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7 The interior of a star has conditions that are ideal for sustainable fusion reactions.
Which of the following are the general conditions required for sustainable fusion?

☒ **A** large amount of hydrogen and very high temperature

☒ **B** large amount of hydrogen and very high pressure

☒ **C** very high density and very high pressure

☒ **D** very high density and very high temperature

(Total for Question 7 = 1 mark)

8 Radioactive decay is a random process.
Which of the following statements about radioactive decay is correct?

☒ **A** We are not able to predict when a particular nucleus will decay.

☒ **B** We are not able to predict the number of nuclei that will decay in a second.

☒ **C** We do not know what a particular nucleus will decay into.

☒ **D** We are able to influence when a particular nucleus will decay.

(Total for Question 8 = 1 mark)

9 Stellar parallax can be used to determine the distances to stars that are relatively close to the Earth.

Which of the following is the reason that this method is unsuitable for more distant stars?

☒ **A** The luminosity of these stars is too high.

☒ **B** The luminosity of these stars is too low.

☒ **C** The parallax angle is too large.

☒ **D** The parallax angle is too small.

(Total for Question 9 = 1 mark)

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10 At the surface of the Earth the gravitational potential is V and the gravitational force on an object is F. The radius of the Earth is R.
The object is moved to a height $2R$ above the surface of the Earth.

Select the row of the table that gives the gravitational potential and gravitational force at height $2R$.

	Gravitational force	Gravitational potential
☒ **A**	$\frac{F}{4}$	$-\frac{V}{2}$
☒ **B**	$\frac{F}{9}$	$-\frac{V}{3}$
☒ **C**	$\frac{F}{4}$	$-\frac{V}{4}$
☒ **D**	$\frac{F}{9}$	$-\frac{V}{9}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

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SECTION B

Answer ALL questions.

11 When nearby stars are observed over a number of years, the stars are seen to undergo a very small movement against the background of more distant stars.

Describe how astronomers use this movement to calculate the distance to a nearby star.

(3)

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(Total for Question 11 = 3 marks)

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12 An electric kettle is used to heat water to make coffee. The kettle has a power of 2.80 kW. Each cup of coffee requires 325 g of hot water.

(a) The kettle is used to heat water for 3 cups of coffee.

Calculate the time taken to increase the temperature of the water from 8.5 °C to 100 °C.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

(3)

Time taken = ...

(b) When the water in the kettle is boiling at a steady rate, some energy is transferred to the steam and some to the surroundings.
A mass of 136 g of steam is produced in 125 seconds.

Calculate the rate of transfer of thermal energy to the surroundings during this time.

specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

(3)

Rate of transfer of thermal energy = ...

(Total for Question 12 = 6 marks)

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13 Adding uranium to a glass mix gives the glass a yellow-green colour. In the last century this glass was often made into decorative items such as vases.



(https://carlwillis.files.wordpress.com/2010/05/vase_melstrom.jpg)

(a) Naturally-occurring uranium mostly consists of uranium-238. Uranium-238 undergoes alpha decay to produce an unstable isotope of thorium.

Complete the nuclear equation for this decay.

(2)

$$^{238}_{92}\mathrm{U} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Th} + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

(b) The activity of a vase is measured to be 36.7 Bq.

(i) Calculate the number of uranium nuclei in the vase.

half-life of uranium = 1.41×10^{17} s

(3)

Number of uranium nuclei = ...

(ii) Suggest why your calculation may overestimate the number of uranium nuclei in the vase.

(1)

(Total for Question 13 = 6 marks)

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14 A balloon is filled with helium gas at a pressure of 1.10×10^5 Pa and a temperature of 23.5 °C. The balloon has a volume of 0.0142 m^3.

(a) Calculate the number of helium atoms in the balloon.

(3)

Number of helium atoms = ...

(b) Explain why the volume of the balloon will increase if the temperature of the helium is increased.

(2)

(Total for Question 14 = 5 marks)

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15 During the process of fusion, changes in binding energy may result in the release of energy from the nucleus.

(a) State what is meant by the binding energy of a nucleus.

(1)

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(b) Data for the masses of some particles are given in the table.

particle	mass / u
proton	1.00728
neutron	1.00867
tritium nucleus	3.01551

(i) Calculate the binding energy, in MeV, of a tritium nucleus, ${}^{3}_{1}\mathrm{H}$.

(4)

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Binding energy = ... MeV

(ii) Explain why the fusion of massive nuclei does not release energy.

(2)

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(Total for Question 15 = 7 marks)

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16 The luminosity of the Sun is 3.85×10^{26} W.

(a) Calculate the radius of the Sun.

surface temperature of the Sun = 5800 K

(2)

Radius of the Sun = ...

(b) A solar array is a combination of solar cells. A solar array covers an area of 250 000 m^2.

Calculate the maximum electrical power that can be supplied by this solar array.

percentage of solar power dissipated in the atmosphere = 25%
efficiency of the solar array = 22%
distance of the Sun from the Earth = $1{\cdot}50 \times 10^{11}$ m

(5)

(Total for Question 16 = 7 marks)

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17 In November 1940 the wind caused oscillations of the road bridge over Tacoma Narrows in the United States. The amplitude of the oscillations became so large that the bridge collapsed.

(a) Name the effect that caused the bridge to oscillate with increasing amplitude.

(1)

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(b) The vertical oscillations of the bridge can be modelled using the equations of simple harmonic motion. Calculate the maximum acceleration of the bridge when it was oscillating 38 times per minute and the amplitude of its oscillations was 0.90 m.

(4)

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Maximum acceleration = ...

(c) As the amplitude of the vertical oscillations increased, people left the bridge leaving their cars behind.

(i) Complete a free-body force diagram for a car in contact with the road surface of the bridge.

(1)

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(ii) Assess the validity of the suggestion that at certain points in the oscillation of the bridge any car would lose contact with the road.

(3)

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(Total for Question 17 = 9 marks)

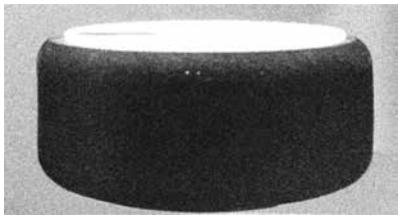
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18 The photograph shows a battery-powered toy that floats on a cushion of air over any smooth, flat surface.

A fan expels air from underneath the toy, allowing the toy to float a few millimetres above the surface, ensuring that the toy can move freely.



top view



side view

(a) Explain how the action of the fan allows the toy to float a small distance above the surface.

(3)

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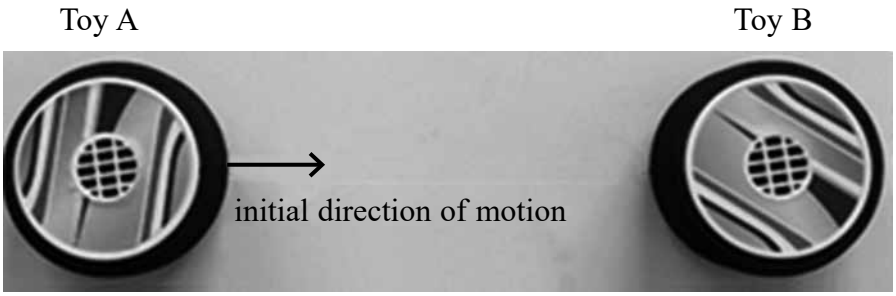
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*(b) A teacher uses two of the toys, A and B, in a demonstration. Toy A moves towards toy B, which is initially stationary. The two toys collide.



The teacher states 'Applying Newton's 2nd and 3rd laws of motion to this collision leads to the conclusion that momentum is conserved.'.

Justify this statement.

(6)

(Total for Question 18 = 9 marks)

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19 A swing consists of a tyre suspended by nylon ropes of negligible mass as shown.



When pulled back slightly from its rest position and released, the tyre moves with simple harmonic motion.

(a) State what is meant by simple harmonic motion.

(2)

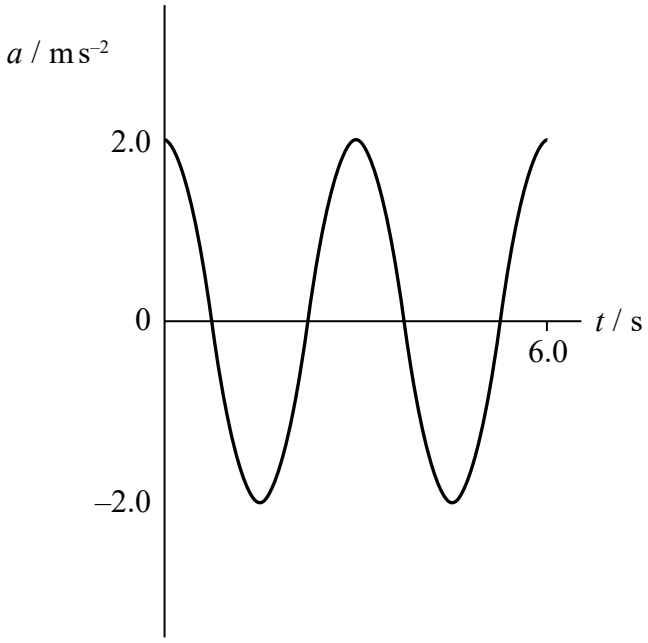
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(b) The sketch graph shows how acceleration varies with time for the tyre.



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(i) Show that the amplitude of the motion is about 0.5 m.

(3)

(ii) Calculate the maximum velocity of the tyre.

(2)

Maximum velocity of tyre = ...

(iii) Draw a line on the graph to show how the velocity of the tyre varies with time.

(2)

(Total for Question 19 = 9 marks)

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20 A satellite of mass m is in orbit around the Earth. The radius of the orbit is r.

(a) (i) The gravitational field strength g at a distance r from the centre of the Earth is given by

$$g = \frac{GM}{r^2}$$

where M is the mass of the Earth.

Derive this equation.

(2)

(ii) On an astrophysics website it states.

"For all satellites in a circular orbit

$$T^2 \propto r^3$$

where T is the period of the orbit and r is the radius of the orbit."

Justify this statement.

(4)

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(b) Some satellites are in low Earth orbits. These orbits have a radius approximately equal to the radius of the Earth R_E. A satellite in a low Earth orbit has a time period of 88 minutes.

Some satellites are in a geostationary orbit. These satellites are always above the same point on the surface of the Earth.

(i) Determine, using the expression in (a)(ii), the height of a satellite in a geostationary orbit.

$R_E = 6.4 \times 10^6$ m

(3)

(ii) Suggest why a satellite has to be over the equator to remain in a geostationary orbit.

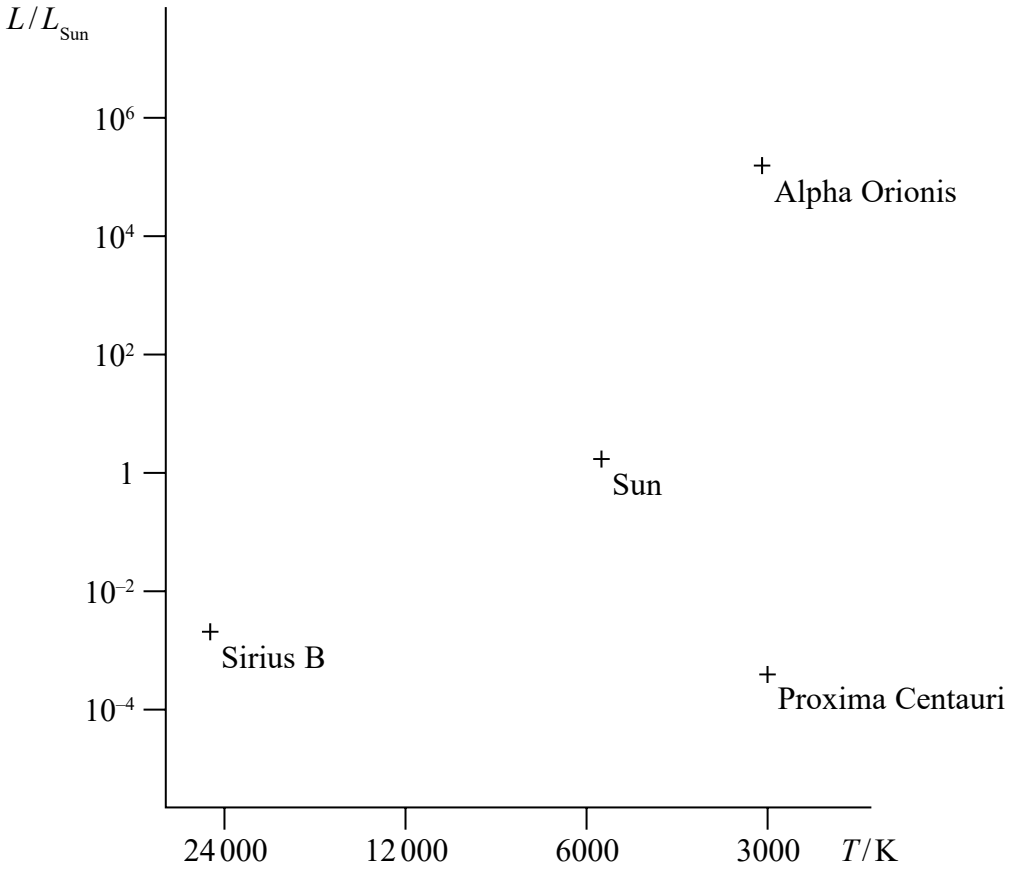
(1)

(Total for Question 20 = 10 marks)

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21 A Hertzsprung-Russell (HR) diagram shows the relationship between the luminosity and surface temperature of stars.

The positions of three stars and the Sun are indicated on the HR diagram shown.



(a) The Sun is a main sequence star.

(i) State what is meant by a main sequence star.

(1)

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(ii) Draw the main sequence region on the HR diagram above.

(1)

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(b) On an astronomy website it states that:

"Alpha Orionis has a much smaller radius than Proxima Centauri. Both stars appear the same colour when viewed through a telescope."

(i) Assess the validity of this statement.

(4)

(ii) Explain the differences between Sirius B and Proxima Centauri.

(3)

(Total for Question 21 = 9 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

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