Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Wednesday 21 June 2017 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or 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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care on these questions with your spelling, punctuation and grammar, as well as the clarity of expression.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

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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Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 Astronomers identify standard candles to allow them to calculate the

☐ **A** brightness of stars.

☐ **B** distances to stars.

☐ **C** luminosity of stars.

☐ **D** size of stars.

(Total for Question 1 = 1 mark)

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2 α, β and γ radiation are all able to penetrate matter.

Select the row in the table which correctly identifies the penetration and ionising ability of γ radiation.

	Penetration	Ionising ability
☐ **A**	High	High
☐ **B**	Low	High
☐ **C**	High	Low
☐ **D**	Low	Low

(Total for Question 2 = 1 mark)

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3 Radioactive decay is a spontaneous process.

This means that we cannot

☐ **A** influence how a nucleus will decay.

☐ **B** influence when a nucleus will decay.

☐ **C** know how much energy is emitted.

☐ **D** know what radiation will be emitted.

(Total for Question 3 = 1 mark)

P 4 8 1 0 7 A 0 2 2 4

4 A cylinder contains a mixture of argon gas and neon gas. Argon molecules are twice as massive as neon molecules.

The value of the ratio $\dfrac{\text{mean square speed of argon molecules}}{\text{mean square speed of neon molecules}}$ is

☒ **A** 4

☒ **B** 2

☒ **C** $\dfrac{1}{2}$

☒ **D** $\dfrac{1}{4}$

(Total for Question 4 = 1 mark)

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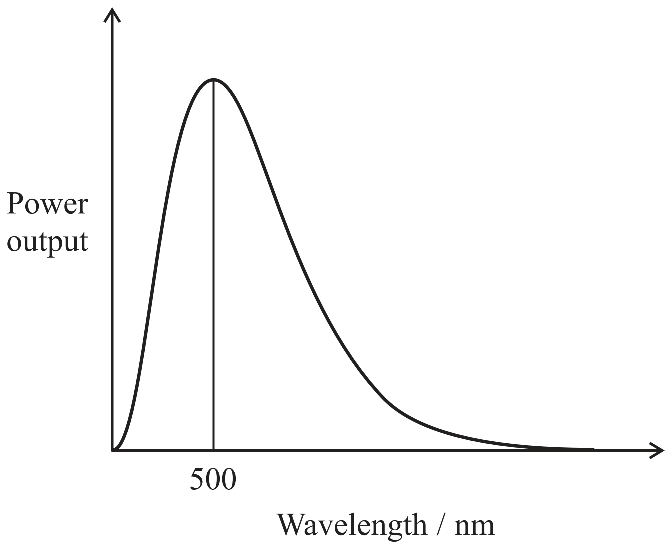
5 The power output of the Sun peaks at a wavelength of 500 nm, as shown.



Another star had the same surface area as the Sun but a higher surface temperature.

The peak of the power output of this star compared to that of the Sun would be

☒ **A** higher and shifted towards the left

☒ **B** higher and shifted towards the right

☒ **C** the same height and shifted towards the left

☒ **D** the same height and shifted towards the right

(Total for Question 5 = 1 mark)

6 Buildings designed to resist earthquake damage often utilise steel structures.

Why is steel particularly good at providing energy dissipation?

☒ **A** Steel is ductile and able to deform plastically.

☒ **B** Steel is hard and able to deform plastically.

☒ **C** Steel is stiff and able to resist deformation.

☒ **D** Steel is strong and able to resist deformation.

(Total for Question 6 = 1 mark)

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7 Stellar parallax is used by astronomers to determine the distances to stars.

What data must be known in addition to the parallax angle?

☒ **A** the diameter of the Earth

☒ **B** the luminosity of the star

☒ **C** the distance to the fixed star background

☒ **D** the diameter of the Earth's orbit about the Sun

(Total for Question 7 = 1 mark)

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8 Charged particles produce both electrostatic and gravitational fields.

Which of the following statements applies to both fields?

☒ **A** Field strength at a point is inversely proportional to the distance from the particle.

☒ **B** Field strength can only be zero at infinity.

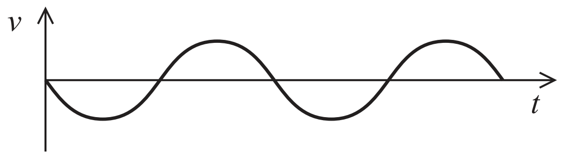
☒ **C** Forces between particles can be attractive or repulsive.

☒ **D** Force is inversely proportional to the square of distance between particles.

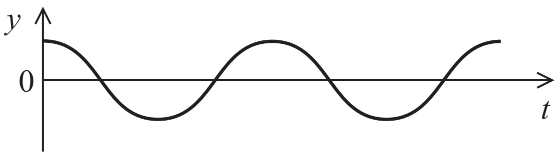
(Total for Question 8 = 1 mark)

Questions 9 and 10 relate to the graph below.

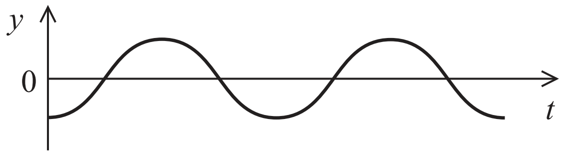
The graph shows how the velocity *v* varies with time *t* for an object undergoing simple harmonic motion.



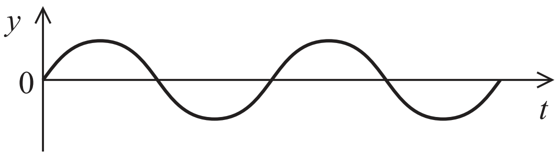
The following graphs show how other quantities for the object may vary over the same time interval.



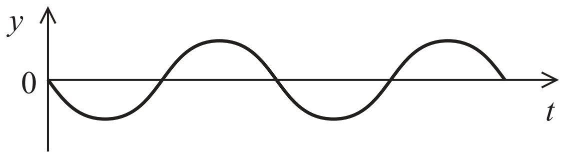
A



B



C



D

9 Which graph shows how the displacement of the object from the equilibrium position varies with time *t*?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

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10 Which graph shows how the acceleration of the object varies with time *t*?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A carton containing 1.03 kg of milk is placed in a refrigerator. The milk cools from 22.5 °C to 3.5 °C over a period of 115 minutes.

Calculate the average rate at which energy is transferred from the milk as it cools.

specific heat capacity of milk = 3930 J kg^{-1} K^{-1}

(3)

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Average rate of energy transfer = ...

(Total for Question 11 = 3 marks)

12 A beach volleyball has a fixed volume of 5.10×10^{-3} m^3. The volleyball is filled with air at a pressure of 1.24×10^5 Pa at a temperature of 25.0 °C.

(a) The temperature of the air drops to 0 °C. The volume of the volleyball remains constant.

Show that the pressure exerted by the air inside the volleyball is now about 1.1×10^5 Pa.

(3)

(b) The temperature of the air inside the volleyball remains at 0 °C.

Calculate the number of air molecules which must be pumped into the volleyball to return the pressure to 1.24×10^5 Pa.

(2)

Number of air molecules = ...

(Total for Question 12 = 5 marks)

13 Stars are formed when gas clouds contract under gravitational forces. If the mass of the contracting gas cloud is large enough, fusion will take place and hydrogen will begin to fuse into helium.

(a) State what is meant by fusion.

(2)

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*(b) Explain why the fusion of hydrogen into helium in stars releases large amounts of energy.

(3)

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(c) Explain the conditions necessary for fusion reactions to take place in a star.

(2)

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(Total for Question 13 = 7 marks)

14 In the early twentieth century astronomers used the Doppler shift to study the motion of galaxies.

*(a) State what is meant by a Doppler shift and describe how it was used to study the movement of galaxies.

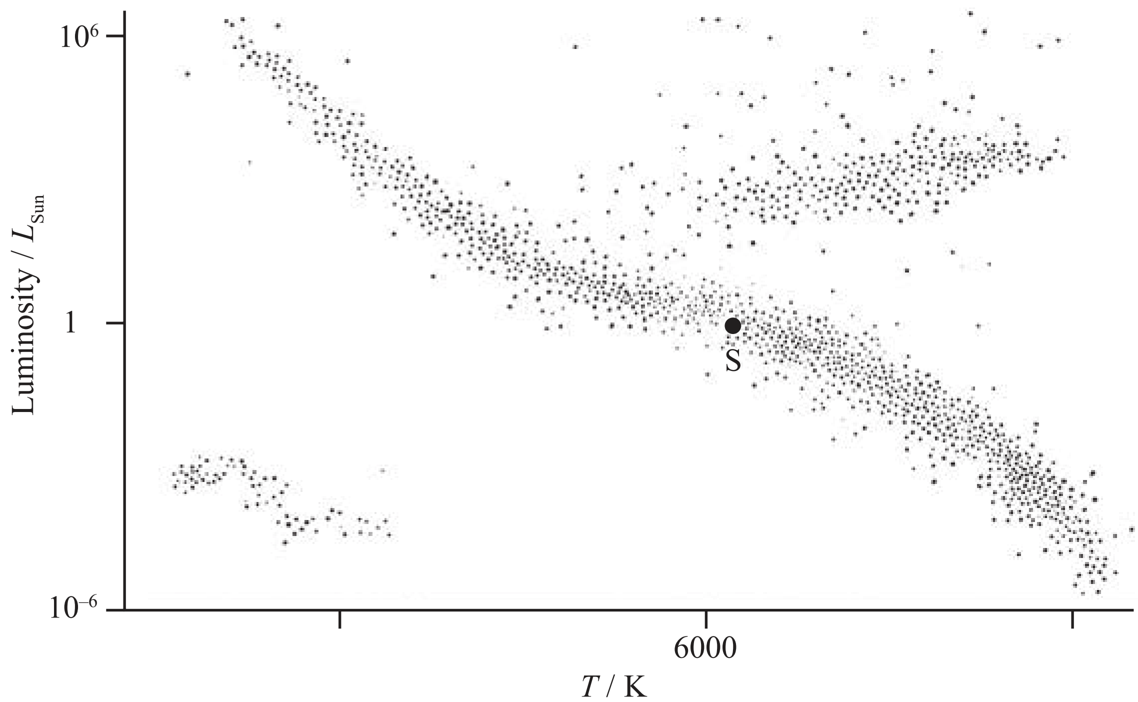
(4)

(b) Explain why astronomers have concluded that the universe is expanding.

(3)

(Total for Question 14 = 7 marks)

15 The Hertzsprung-Russell (H-R) diagram is a scatter graph showing the relationship between the luminosity of stars and their temperatures.
The H-R diagram below shows a large number of stars and the position S of our Sun.



(a) (i) Add two temperatures to the horizontal axis to indicate the scale.

(2)

(ii) A star is identified as having a surface temperature of about 10 000 K and a luminosity one thousandth of the Sun's luminosity.

Explain why this star is an example of a white dwarf.

(2)

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(iii) Add two lines to the H-R diagram to indicate the evolution of the Sun once it moves off the main sequence.

(2)

*(b) The Sun is predicted to be on the main sequence for about 9 billion years.

Explain why the Sun will eventually move off the main sequence.

(3)

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(Total for Question 15 = 9 marks)

16 The photograph shows a "flying pig" toy that contains a solar cell. The toy uses energy from the Sun to make the pig's wings move up and down. When the solar cell is illuminated, the pig's wings oscillate with simple harmonic motion.

(a) State the conditions for an object to move with simple harmonic motion.

(2)

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(b) The time t for 25 oscillations of the wings is measured three times and the values obtained are recorded in the table.

t_1/s	t_2/s	t_3/s
16.3	16.1	16.3

(i) Show that the wings oscillate with a frequency of about 1.5 Hz.

(3)

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(ii) When the wings move from the highest position to the lowest position, the distance moved is 0.90 cm.

Calculate the maximum speed of the tips of the wings.

(3)

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Maximum speed = ...

(c) Under certain conditions, many oscillating systems demonstrate resonance.

(i) State what is meant by resonance.

(3)

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(ii) Describe a situation in which resonance is essential.

(2)

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(Total for Question 16 = 13 marks)

17 In 2015 Chinese scientists were considering a plan to build and put into orbit a massive space station that would supply energy to Earth.

The project would involve placing the space station in a geostationary orbit. The space station would be equipped with large solar panels. The space station would then transfer energy to Earth as microwaves.

(a) The solar constant is the rate at which radiation energy from the Sun is incident per unit area at the top of the Earth's atmosphere.

(i) Show that the solar constant is about 1.4 kW m^{-2}.

radius of Sun = 6.96×10^8 m
surface temperature of Sun = 5790 K
distance from Sun to Earth = 1.50×10^{11} m

(3)

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(ii) The solar panels on the space station have an efficiency of 22%.

Calculate the useful power output from the solar panels.

surface area of solar panels = 6.0 km^2

(3)

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Useful power output = ...

(b) The space station is to orbit at the same rate as the Earth's rotation.

Calculate the height of the space station above the surface of the Earth.

mass of Earth = 5.98×10^{24} kg
radius of Earth = 6.36×10^{6} m

(4)

Height of space station = ...

(c) Space-based solar panels could generate much more electrical power than ground-based solar panels.

Suggest why.

(2)

(Total for Question 17 = 12 marks)

18 Caesium-137 is a radioactive isotope found in the waste from nuclear power stations.

(a) Complete the nuclear equation which represents the decay of caesium-137.

(2)

$$^{137}_{55}\text{Cs} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Ba} + {}^{\cdots\cdots}_{\cdots\cdots}\beta^{-}$$

(b) Calculate the energy released, in joules, in the decay of caesium-137 by β^- emission.

(3)

	Mass / MeV/c²
Cs	127 528.953
Ba	127 527.266
β^-	0.511

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Energy released = ... J

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(c) A sample of caesium-137 is used to demonstrate the properties of β^- radiation.

State two precautions that should be taken when carrying out this demonstration.

(2)

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(d) This sample of caesium-137 contains 2.22×10^{15} atoms.

(i) Calculate the activity of this sample of caesium-137.

half-life of caesium = 30.2 years

(4)

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Activity = ...

(ii) Each year, the waste from a particular nuclear fission reactor contains up to 25 kg of caesium-137.
It is claimed that when the activity of 1 kg of caesium-137 has dropped below 2.0 kBq, it can be disposed of safely by scattering on the ground.
A student suggests that this would take less than a human lifetime.

Calculate the time taken for the activity of 1 kg of caesium-137 to drop below 2.0 kBq and hence comment on the student's suggestion.

initial activity of 1 kg of caesium = 3.2×10^{15} Bq

(3)

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(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19} \text{ C}$	
Electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8} \text{ m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	

Unit 1

Mechanics

Kinematic equations of motion
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Forces
$\Sigma F = ma$
$g = F/m$
$W = mg$

Work and energy
$\Delta W = F\Delta s$
$E_k = \frac{1}{2}mv^2$
$\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus
$E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

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Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{1/2}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$