Write your name here

Surname	Other names

Edexcel GCE

Centre Number | Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Monday 18 June 2012 – 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 with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- 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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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 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 upon 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 1 = 1 mark)

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2 Before carrying out an experiment to measure the activity from a radioactive source, it is usual to measure the background count. The background count obtained is **not** affected by the

☐ **A** location of the experiment.

☐ **B** temperature of the surroundings.

☐ **C** time interval used for the count.

☐ **D** type of detector being used.

(Total for Question 2 = 1 mark)

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3 Health and safety guidelines state that radioactive sources suitable for school experiments should only be handled using long tongs, and only for restricted periods of time. Select the row in the table that gives the type of radiation that is most dangerous to the human body, in these circumstances, with the correct reason.

	Type of radiation	Reason
☐ **A**	α-radiation	it is the most ionising
☐ **B**	α-radiation	it is the most massive
☐ **C**	β-radiation	it can penetrate up to a metre of air
☐ **D**	β-radiation	it can penetrate the skin and enter the body

(Total for Question 3 = 1 mark)

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4 Which of the following is **not** an example of simple harmonic motion?

☒ **A** A car bouncing on its suspension system.

☒ **B** A child jumping on a trampoline.

☒ **C** A person bouncing on the end of a bungee cord.

☒ **D** A swinging pendulum in a grandfather clock.

(Total for Question 4 = 1 mark)

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5 Two distant stars are observed through a telescope. Star A is observed to be half as bright as star B. Star A is calculated to be twice as far away as star B.

Which of the following is correct?

☒ **A** Star A has half the luminosity of star B.

☒ **B** Star A has the same luminosity as star B.

☒ **C** Star A has twice the luminosity of star B.

☒ **D** Star A has 8 times the luminosity of star B.

(Total for Question 5 = 1 mark)

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6 The electrostatic interaction between two charges and the gravitational interaction between two masses can be represented by similar equations.

Which of the following is correct?

☒ **A** The force variation in both fields obeys an inverse square law.

☒ **B** Both fields are examples of strong interactions.

☒ **C** Both have a field strength variation that is inversely proportional to distance.

☒ **D** Electric charge is exactly analogous to mass.

(Total for Question 6 = 1 mark)

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7 When one system is driven into oscillation by another, the driven system

☒ **A** exhibits resonance.

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

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

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

(Total for Question 7 = 1 mark)

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8 The interior of a star has conditions that are ideal for sustainable fusion reactions.
The general conditions for fusion require a very large

☒ **A** amount of hydrogen and temperature.

☒ **B** amount of hydrogen and pressure.

☒ **C** density and pressure.

☒ **D** density and temperature.

(Total for Question 8 = 1 mark)

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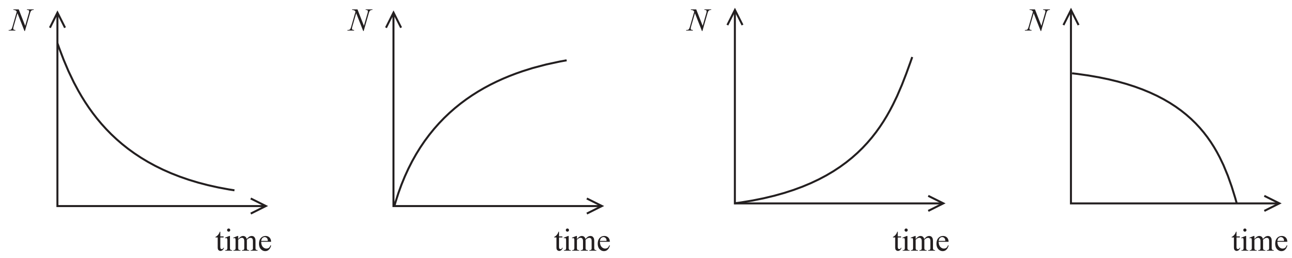
9 Some rocks contain lead as a result of radioactive decay. In one such decay a fixed amount of polonium decays to a stable isotope of lead.

Which graph correctly shows the variation with time of the number of lead atoms, *N*, produced from the decay of polonium in the rock.



A **B** **C** **D**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

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10 Current theories give a number of alternatives for the future evolution of our universe.
According to current theory, an open universe

☒ **A** eventually reaches a maximum size.

☒ **B** expands forever.

☒ **C** has an unpredictable future.

☒ **D** is a steady state universe.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 In 1965, two American scientists, Penzias and Wilson, were testing a very sensitive microwave detector. They discovered that the detector was picking up microwave "noise" at a frequency of 160 GHz that appeared to come from all directions equally. Upon investigation they found that the "noise" was the same day and night, throughout the year.

Suggest how this microwave "noise" may show evidence for an expanding universe.

(3)

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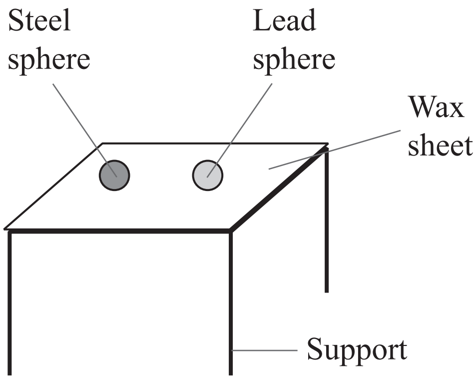
(Total for Question 11 = 3 marks)

12 Two metal spheres of the same size are heated to a temperature of 100 °C in a water bath. One of the spheres is made of lead and the other of steel. The spheres are then placed onto a sheet of paraffin wax as shown. Paraffin wax melts at 55 °C.



	Mass / g	**Specific heat capacity /J kg^{-1} K^{-1}**
Lead sphere	50	130
Steel sphere	34	490

(a) The steel sphere melts through the wax sheet and drops to the floor. The temperature of the steel sphere when it reaches the floor is 53 °C.

Calculate the thermal energy lost by the steel sphere from the time when it was removed from the water bath.

(2)

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Thermal energy lost = ...

(b) The lead sphere is only able to partially melt the wax, so does not drop to the floor.

Explain this observation.

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(Total for Question 12 = 4 marks)

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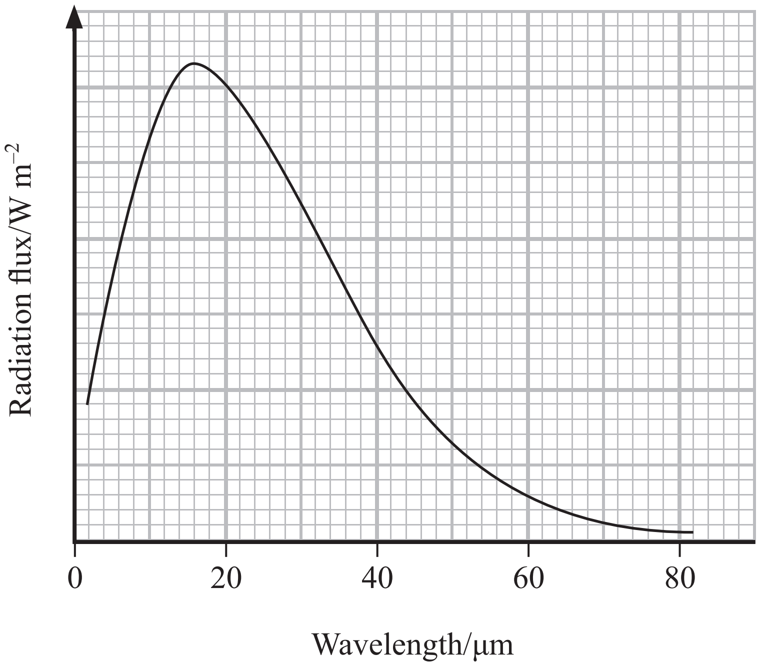
13 The radiation emitted from an asteroid is monitored and the following spectrum obtained.



(a) (i) State the wavelength at which the peak radiation flux from the asteroid occurs.

(1)

Wavelength of peak radiation flux = ...

(ii) Use the data to estimate the temperature of the asteroid.

(2)

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Temperature of asteroid = ...

(b) The asteroid is in a circular orbit, of known radius, about the Sun. The average speed of the asteroid cannot be determined directly.

State the two extra data values that you would need in order to calculate the orbital period of the asteroid.

(2)

1 ....

2 ....

(c) This asteroid is about 1.5×10^{11} m from the planet Jupiter.

Calculate the magnitude of the gravitational field strength of Jupiter at this distance.

mass of Jupiter = 1.9×10^{27} kg

(2)

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Gravitational field strength of Jupiter = ...

(Total for Question 13 = 7 marks)

14 A magazine article states that an inflated balloon contains about two hundred billion trillion (2×10^{23}) air molecules.

(a) Taking the balloon to be a sphere of volume 8.2×10^{-3} m^3 in a room at a temperature of 22 °C, show that this figure for the number of molecules is correct.

pressure of air in balloon = 1.1×10^5 Pa

(2)

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*(b) The article also states that the internal energy of the air in the balloon could become zero if the temperature of the gas became low enough.

Explain what is meant by the internal energy of the air and discuss whether the statement is correct.

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(Total for Question 14 = 6 marks)

15 (a) Astronomers determine the distance to a nearby star using trigonometric parallax.

Describe the measurements that must be taken to determine this distance.

You may use a diagram to aid your description.

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*(b) Radiation received at the Earth from a distant galaxy is redshifted. The distance to the galaxy can be determined from this redshift.

State what is meant by redshift, and explain how it allows the distance to the galaxy to be determined.

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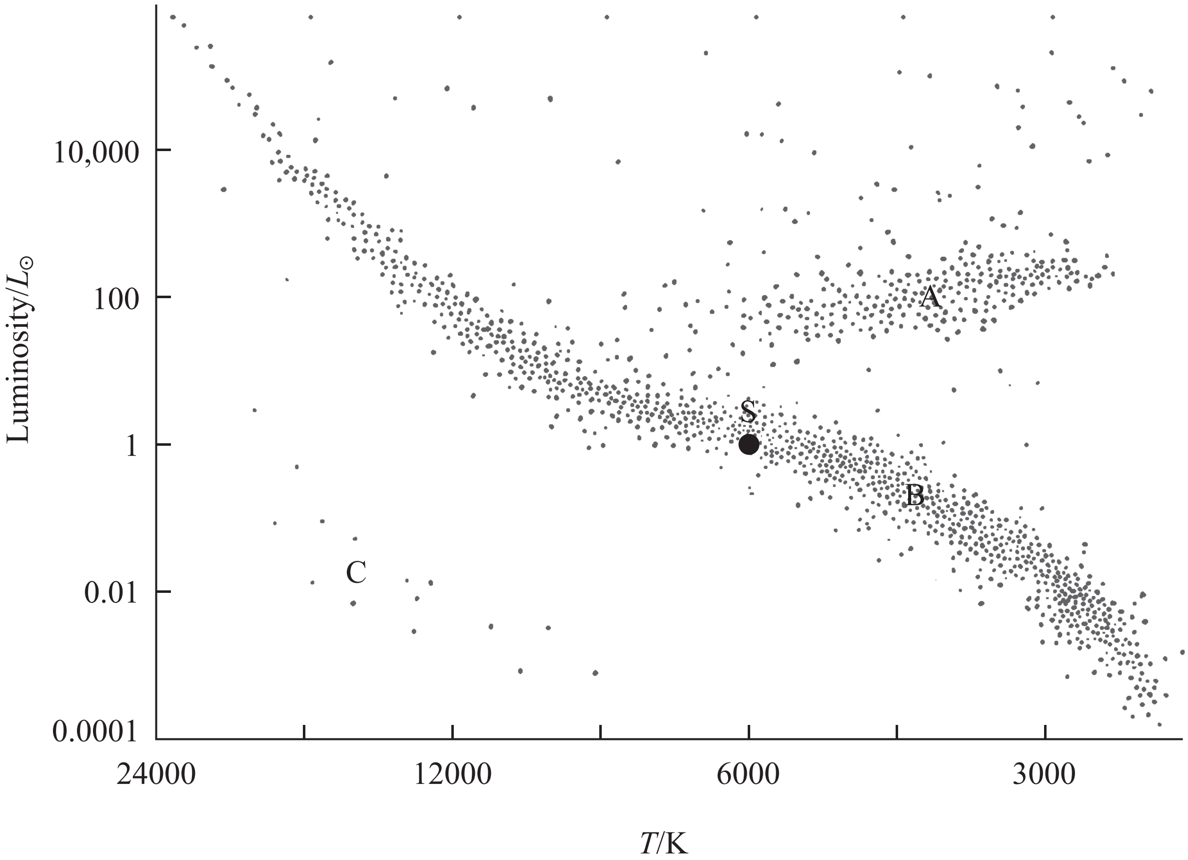
(Total for Question 15 = 6 marks)

16 (a) The position of our Sun, S is shown on the Hertzsprung-Russell (H-R) diagram below.



(i) Identify the three main regions of the H-R diagram.

(3)

Region A = ...

Region B = ...

Region C = ...

(ii) Add lines to the diagram to show the evolutionary path of our Sun from the time when it comes to the end of its hydrogen-burning phase.

(2)

(b) Most stars are too far away from the Earth for astronomers to observe them as anything more than a point source of radiation.

Explain how astronomers calculate the sizes of these stars using information from the H-R diagram.

(3)

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(Total for Question 16 = 8 marks)

17 The photograph shows a nodding tiger toy. The tiger is placed on a car's dashboard and its head nods up and down as the car is driven along a rough road surface.

It is noticed that at a particular speed the tiger's head vibrates with maximum amplitude.

(a) (i) What is the name of this phenomenon?

(1)

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(ii) Describe the conditions necessary for this phenomenon to occur.

(2)

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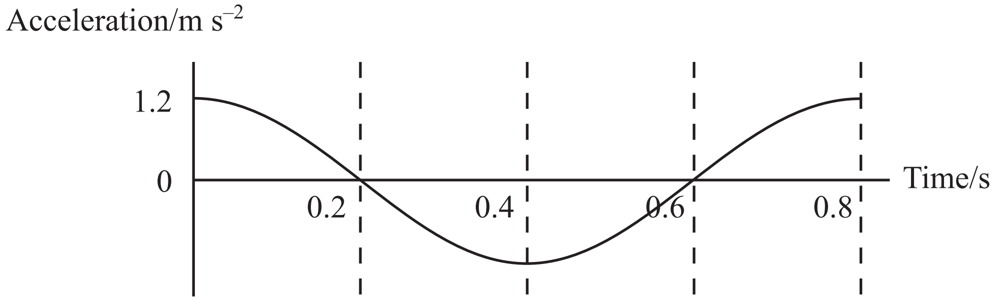
(b) (i) The graph shows the variation of acceleration with time for the tiger's head. Using values from the graph calculate the amplitude of oscillation of the tiger's head.

(3)



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Amplitude of oscillation = ...

(ii) Sketch a graph of the head's displacement against time over the same time interval on the axes below.

(2)

(Total for Question 17 = 8 marks)

18 In a demonstration to her class, a teacher pours popcorn kernels onto a hot surface and waits for them to pop. The kernels pop one by one. There is a large rate of popping at first and this rate decreases as time goes on. However, the order in which the kernels pop cannot be predicted.

*(a) How realistic is this demonstration as an analogy to radioactive decay? Consider aspects of the demonstration that are similar to radioactive decay and aspects that are different.

(4)

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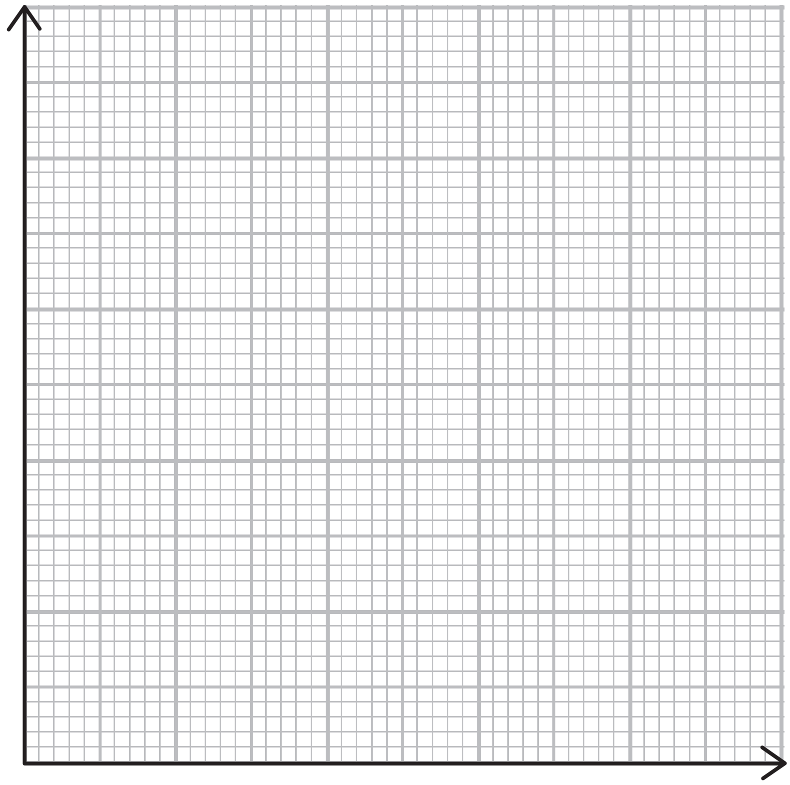
(b) In another demonstration, bags of popcorn are placed in a microwave oven for different lengths of time. Initially, each bag contains the same number of kernels. Once the bags are removed from the oven they are opened and the number of unpopped kernels counted. Assume that the popcorn obeys a similar rule to radioactive decay.

The results from the demonstration are shown in the table:

Time in oven / s	Number of unpopped kernels, N	ln (N)
0	100	4.61
30	78	4.36
60	61	4.11
90	47	3.85
120	37	3.61
150	29	3.37

(i) Use the data to draw a graph to show that the half-life of this process is about 80 s.

(6)



Half-life of popcorn = ...

(ii) A bag of popcorn is placed in the microwave oven until three quarters of the kernels have popped.

Determine the time for which the bag is in the oven.

(1)

Time = ...

(Total for Question 18 = 11 marks)

19 In 2010 The National Ignition Facility (NIF) in California began experiments to produce viable fusion. They used an extremely powerful laser to fuse hydrogen nuclei.

The following “recipe for a small star” was found on the NIF website:

- Take a hollow, spherical, plastic capsule about 2 mm in diameter.
- Fill it with 150 μg of a mixture of deuterium and tritium, the two heavy isotopes of hydrogen.
- Take a laser that for about 15 ns can generate 500×10^{12} W.
- Focus all this laser power onto the surface of the capsule.
- Wait at least 10 ns.

Result: one miniature star.

(a) Give one similarity and one difference between the nuclei of deuterium and tritium.

(2)

Similarity ....

Difference ....

(b) Show that the energy supplied by the laser in a time period of 15 ns is about 8 MJ.

(2)

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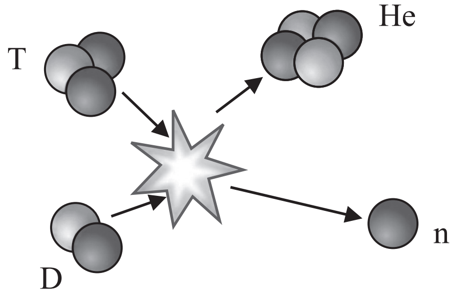
(c) The diagram represents the fusion of deuterium, D, and tritium, T, to form helium, He.



(i) Complete the nuclear equation to represent the fusion of deuterium and tritium to form helium.

(2)

$$^{\cdots}_{\cdots}\mathrm{D} + \, ^{\cdots}_{\cdots}\mathrm{T} \rightarrow \, ^{\cdots}_{\cdots}\mathrm{He} + \, ^{\cdots}_{\cdots}\mathrm{n}$$

(ii) Use the data in the following table to show that about 20 MeV of energy is released when this fusion reaction takes place.

	Mass / MeV/c²
Neutron	939.6
Deuterium	1875.6
Tritium	2808.9
Helium	3727.4

(2)

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(iii) Estimate the number of fusions that need to take place in 15 ns if the “miniature star” is to produce the same amount of energy as the laser supplies.

(2)

Number of fusions = ...

(iv) Calculate the kinetic energy, in MeV, of the neutron released by the fusion of deuterium and tritium nuclei. Assume that the net momentum of the nuclei before fusion is zero.

(4)

Neutron kinetic energy = ... MeV

(d) Nuclear power stations currently use the process of fission to release energy. Outline the process of fission.

(3)

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(Total for Question 19 = 17 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

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

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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\%\ \text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\%\ \text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

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	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

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

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	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

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	$v = H_0 d$

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