Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Friday 24 May 2019

Morning (Time: 1 hour 35 minutes)	Paper Reference **WPH05/01**

Physics

Advanced
Unit 5: Physics from Creation to Collapse

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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

1/1/1/1/1/

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 Scientists are still working to develop a practical nuclear fusion reactor.

Which of the following explains why controlled nuclear fusion on Earth is difficult to achieve?

☒ **A** Fusion requires very high temperatures.

☒ **B** Fusion requires very high pressures.

☒ **C** Fusion requires large amounts of hydrogen.

☒ **D** Fusion requires strong magnetic fields.

(Total for Question 1 = 1 mark)

2 A student used a detector and counter to determine the count rate near to a radioactive source. She also measured the background count for 10 minutes.

Which of the following must she do to obtain an accurate value for the count rate?

☒ **A** Add the background count to her count rate.

☒ **B** Add the background count rate to her count rate.

☒ **C** Subtract the background count from her count rate.

☒ **D** Subtract the background count rate from her count rate.

(Total for Question 2 = 1 mark)

3 The zero on the kelvin temperature scale is known as the absolute zero of temperature.

Which of the following is a description of absolute zero?

☒ **A** It is the lowest temperature yet reached in a laboratory.

☒ **B** It is the temperature at which hydrogen liquefies.

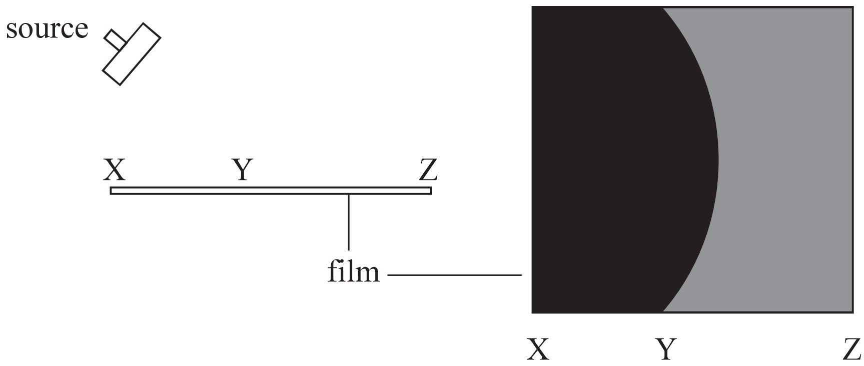
☒ **C** It is the temperature at which molecules have their lowest kinetic energy.

☒ **D** It is the temperature of deep space.

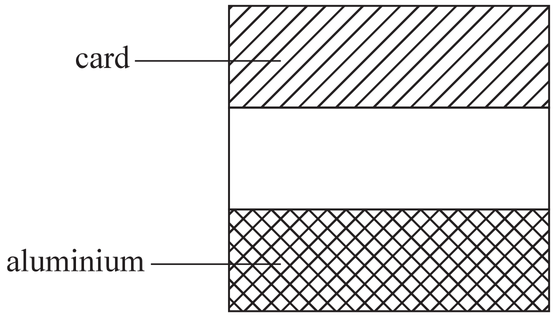
(Total for Question 3 = 1 mark)

4 When exposed to ionising radiation photographic film darkens. The darkness of the film shows how much ionising radiation the film has been exposed to.
A source emitting α, β, and γ radiation was placed a small distance from some photographic film in a light-tight box.

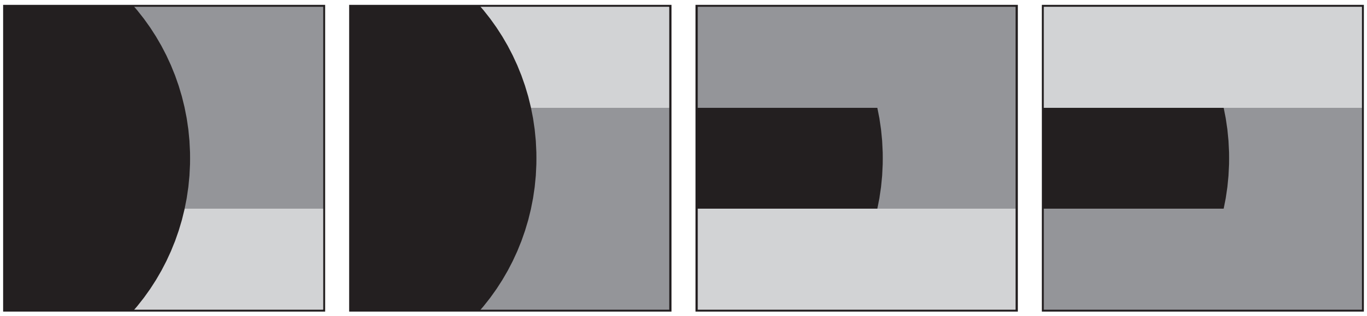
The film became darkened as shown. X, Y and Z are points on the film.



A second film is covered by strips of card and aluminium as shown.



Select the diagram that shows how the film would be darkened with these strips in place.



☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 4 = 1 mark)

5 Two systems are oscillating with simple harmonic motion. The angular frequency and amplitude of each oscillating system are summarised in the table below.

	System 1	**System 2**
angular frequency	ω	$\frac{\omega}{2}$
amplitude	A	$2A$

The maximum acceleration of system 1 is a_1 and the maximum acceleration of system 2 is a_2.

Which of the following expressions is correct?

☒ **A** $a_1 = \frac{a_2}{2}$

☒ **B** $a_1 = a_2$

☒ **C** $a_1 = 2a_2$

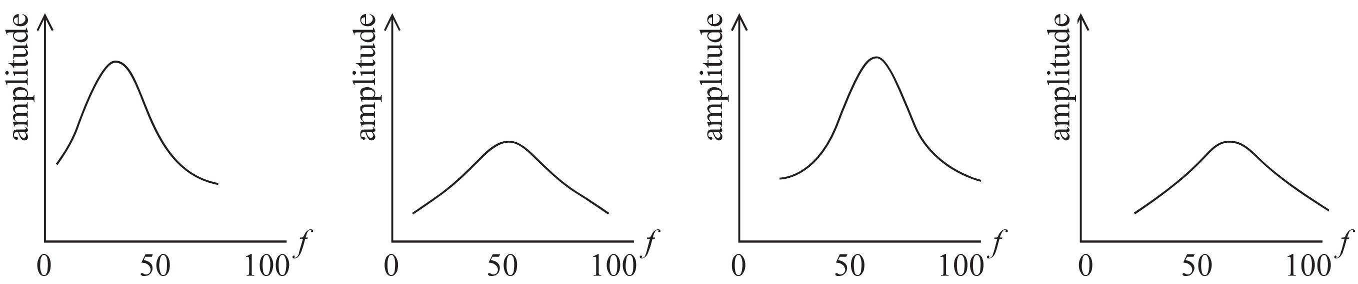
☒ **D** $a_1 = 4a_2$

(Total for Question 5 = 1 mark)

6 A sound engineer is designing a loudspeaker system. She wants the sound produced at a frequency of 50 Hz to be as loud as possible.

The graphs below show how the amplitude of sound produced by four loudspeaker systems varies with frequency f.

Which loudspeaker system should she choose?



☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 6 = 1 mark)

7 Earthquake-proof buildings may include materials in their structure to absorb energy from the movement of the building.

The table shows some properties of two different building materials.

	Material X	**Material Y**
Deforms elastically	✓	✗
Deforms plastically	✗	✓
Stiff	✓	✓
Strong	✗	✓

Which of the following explains the most suitable material to absorb energy from the moving building?

☒ **A** Material X because it is stiff

☒ **B** Material X because it deforms elastically

☒ **C** Material Y because it deforms plastically

☒ **D** Material Y because it is both stiff and strong

(Total for Question 7 = 1 mark)

---

8 Cepheid variable stars are examples of standard candles.

A standard candle is a star with a known

☒ **A** frequency.

☒ **B** luminosity.

☒ **C** radiation flux.

☒ **D** radius.

(Total for Question 8 = 1 mark)

9 Astronomers are collecting data for two stars X and Y. The following observations are made.

	Star X	**Star Y**
parallax angle	θ	2θ
radiation flux	F	$2F$

What can be concluded about the luminosities L_X and L_Y of star X and star Y?

☒ **A** $L_X > L_Y$

☒ **B** $L_X = L_Y$

☒ **C** $L_X = (L_Y)^2$

☒ **D** $L_X < L_Y$

(Total for Question 9 = 1 mark)

10 Wolf 359 is the fifth nearest star to the Sun. It has a surface temperature of 2800 K and a luminosity of $1.4 \times 10^{-3}\ L_{sun}$, where L_{sun} is the luminosity of the Sun.

Which of the following is a correct description of Wolf 359?

☒ **A** a black dwarf star

☒ **B** a main sequence star

☒ **C** a red giant star

☒ **D** a white dwarf star

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

SECTION B

Answer ALL questions in the spaces provided.

11 The air in a train carriage heats up due to the people inside the carriage.

On one journey there are 44 people in the carriage. The temperature of the air in the carriage is initially 16 °C, and rises to 28 °C.

(a) The doors and windows in the carriage are closed.

Calculate the time taken for the temperature of the air in the carriage to rise to 28 °C due to the people in the carriage.

average rate at which one person heats the air = 85 W
mass of air in the carriage = 110 kg
specific heat capacity of air = $720\,\mathrm{J\,kg^{-1}\,K^{-1}}$

(3)

....

....

....

....

....

....

Time taken = ...

(b) Suggest why the actual time taken for the temperature to rise to 28 °C will be greater than the time you have calculated.

(1)

....

....

....

(Total for Question 11 = 4 marks)

12 Most scientists believe that dark matter is spread throughout the whole universe. Recent observations indicate that there may be galaxies in which there is no dark matter.

Discuss how the absence of dark matter in parts of the universe might affect the ultimate fate of the universe.

(4)

....

....

....

....

....

....

....

....

....

....

....

(Total for Question 12 = 4 marks)

13 A cyclist competes in a bicycle race.

Before the race a bicycle tyre contains air at a temperature of 22 °C and a pressure of 5.52×10^5 Pa.

By the end of the race, the pressure of the air in the tyre has risen to 5.60×10^5 Pa.

(a) (i) Calculate the temperature of the air in the tyre at the end of the race.

(3)

....

....

....

....

....

....

....

....

Temperature of air = ...

(ii) During the race, a small amount of air escapes from the tyre.

Explain how the value of the temperature calculated in (i) would be affected if allowance were made for this escaped air.

(2)

....

....

....

....

....

*(b) Explain why the pressure exerted by the air in the tyre increases as the temperature of the air increases.

Your answer should include reference to molecular momentum and kinetic energy.

(4)

(Total for Question 13 = 9 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

14 Caesium-137 is a radioactive isotope found in used fuel rods from a nuclear fission reactor. It is a beta emitter with a half-life of 30.2 years.

(a) Complete the decay equation

(2)

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

(b) When it is removed from a fission reactor, a fuel rod contains 1.36×10^{24} nuclei of caesium-137.

Calculate the activity of the fuel rod due to the decay of the caesium-137 20 years after removal from the reactor.

1 year = 3.15×10^{7} s

(4)

....

....

....

....

....

....

....

Activity of fuel rod = ...

(c) When caesium-137 decays it also emits gamma radiation.

Explain why the emission of gamma radiation is a more serious hazard than the emission of beta radiation.

(2)

....

....

....

....

(Total for Question 14 = 8 marks)

15 Navstar 1 was a navigation satellite placed in a circular orbit about the Earth in 1978. It was the first Global Positioning System satellite to be launched.

(a) (i) Show that the orbital time T for a satellite in a circular orbit of radius r about the Earth of mass M is given by

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

(3)

....

....

....

....

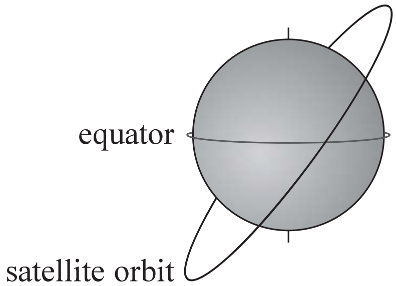
....

....

....

....

(ii) The plane of the satellite's orbit was inclined at an angle to the plane of the equator as shown.



Calculate the number of times that the satellite crossed over the equator each day.

radius of orbit = 2.66×10^{7} m
mass of the Earth = 6.0×10^{24} kg

(3)

Number of times satellite crosses equator = ...

(b) A student calculated the increase in the potential energy of the satellite from launch to its final orbit height. He used the equation $\Delta E_{grav} = mg\Delta h$

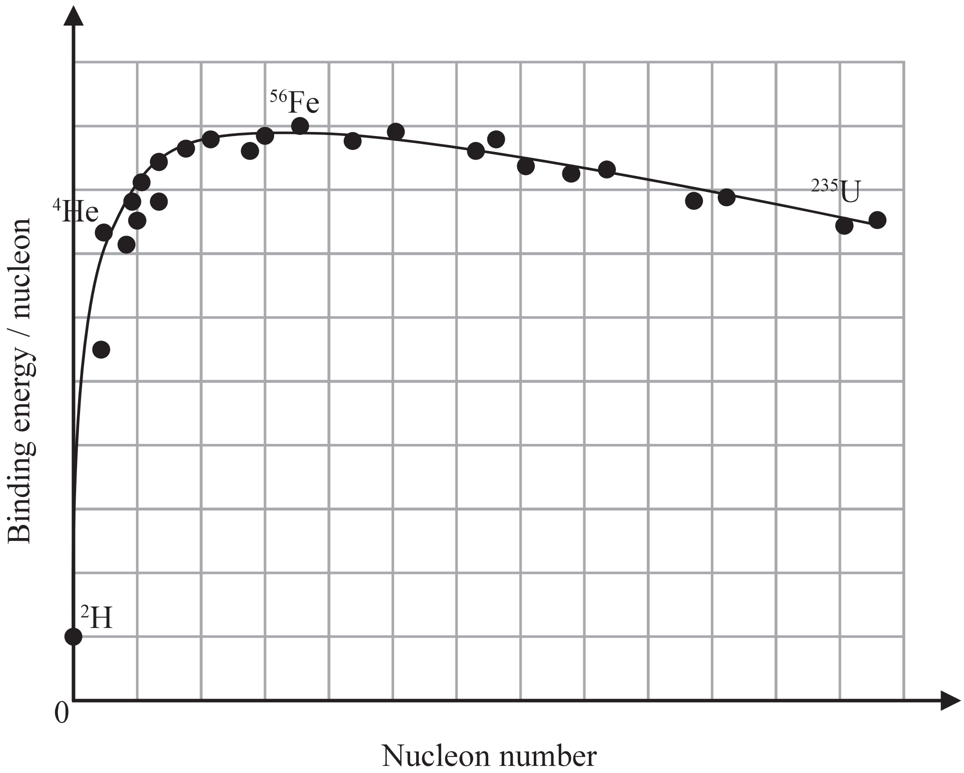
Explain how the actual value for ΔE_{grav} differed from the value calculated using $\Delta E_{grav} = mg\Delta h$

(2)

(Total for Question 15 = 8 marks)

BLANK PAGE

16 The graph shows how the binding energy per nucleon varies with nucleon number for various isotopes.



(a) (i) Explain the significance of the position of ^{56}Fe on this graph.

(2)

....

....

....

....

....

(ii) Show that the binding energy per nucleon of $^{56}_{26}Fe$ is about 9 MeV.

proton mass = 1.673×10^{-27} kg
neutron mass = 1.675×10^{-27} kg
mass of ^{56}Fe nucleus = 9.287×10^{-26} kg

(4)

(iii) Deduce a value for the binding energy per nucleon of ^{2}H.
You should use your value from (ii) and the graph.

(2)

Binding energy per nucleon = ...

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P 5 6 1 4 4 A 0 1 6 2 8

(b) The isotope uranium-235 undergoes fission into less massive isotopes.

Explain how fission of uranium-235 leads to a release of energy.

(2)

....

....

....

....

(Total for Question 16 = 10 marks)

17 A physics textbook gives the following statement about simple harmonic motion:

"Simple harmonic motion occurs when the acceleration of an object is proportional to the displacement from equilibrium."

(a) This statement is not a complete definition of simple harmonic motion.

Rewrite this statement to give a complete definition of simple harmonic motion.

(2)

....

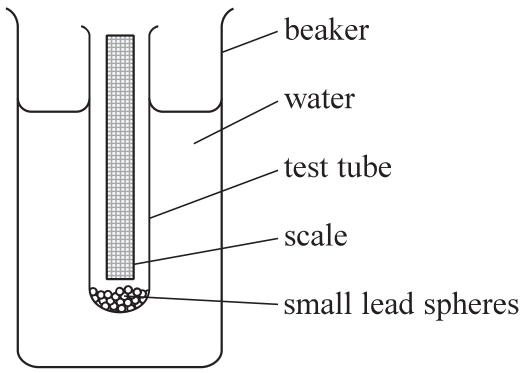
....

....

....

....

(b) A test tube is loaded with small lead spheres so that it floats vertically in a beaker of water as shown.



The test tube is displaced downwards and released. After release the test tube moves with simple harmonic motion.

(i) A student uses a stopwatch to measure the period of oscillation T of the test tube.

Describe the procedure she should follow to obtain an accurate value for T.

(3)

....

....

....

....

....

....

....

(ii) The maximum displacement of the test tube from the equilibrium position is 2.0 cm.

Calculate the maximum velocity of the test tube.

$T = 0.57\,\text{s}$

(3)

....

....

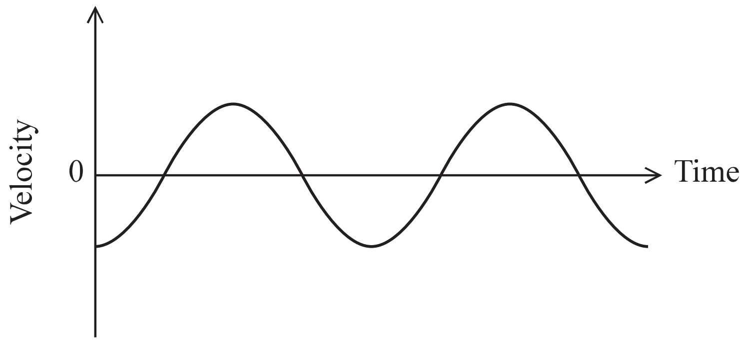
....

....

....

Maximum velocity = ...

(iii) The idealised graph below shows how the velocity of the test tube varies with time.



Add to this graph to show how the acceleration of the test tube varies with time.

(2)

(iv) Explain why the amplitude of the oscillation would decrease with time.

(2)

....

....

....

....

....

(Total for Question 17 = 12 marks)

18 Luyten's star is a low-mass main sequence star. Scientists have recently sent signals to Luyten's star in the search for intelligent life.

(a) The surface temperature of Luyten's star is 3150 K.

(i) Calculate the wavelength at which the power output is a maximum for this star.

(2)

....

....

....

....

....

Wavelength = ...

(ii) The radius of Luyten's star is 35% of the radius of the Sun.

Calculate the ratio of the luminosity L_L of Luyten's star to the luminosity L_S of the Sun.

surface temperature of the Sun = 5800 K

(2)

....

....

....

....

....

$\frac{L_L}{L_S}$ = ...

(iii) The atoms in the outer regions of a star may be treated as an ideal gas. Calculate the mean kinetic energy of the hydrogen atoms in the outer regions of Luyten's star.

(2)

....

....

....

....

Mean kinetic energy = ...

(b) The spectrum produced by hydrogen atoms in the outer regions of Luyten's star shows a strong line at a wavelength of 656.3 nm. The motion of the atoms at the surface of the star causes broadening of this line.

*(i) Explain why the motion of the atoms in the outer regions of the star causes this wavelength to become a range of wavelengths.

(3)

....

....

....

....

....

....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) The broadening of a spectral line of wavelength λ can be estimated by the equation

$$\frac{\Delta\lambda}{\lambda} = \sqrt{\frac{kT}{mc^2}}$$

where $\frac{\Delta\lambda}{\lambda}$ is the Doppler shift in wavelength for an atom of typical speed.

T is the surface temperature of Luyten's star, m is the mass of a hydrogen atom, and c is the speed of light.

Use this equation to calculate the component of the velocity of this atom along the line of sight.

$m = 1.67 \times 10^{-27}\,\text{kg}$

$T = 3150\,\text{K}$

(3)

....

....

....

....

....

Speed of hydrogen atoms = ...

*(c) After a period of time all stars evolve and move off the main sequence.

Explain why we would expect Luyten's star to remain on the main sequence for a longer time than the Sun.

(3)

....

....

....

....

....

....

....

(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(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 $E_{el} = \frac{1}{2}F\Delta x$

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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	$hf = \phi + \frac{1}{2}mv^2_{max}$

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	$Q = Q_0e^{-t/RC}$
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	$\lambda = h/p$

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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

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	$v = H_0 d$

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

BLANK PAGE