Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
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| | |

**Pearson Edexcel International Advanced Level**

| Centre Number | Candidate Number |
|---|---|
| | |

# Monday 1 June 2020

| Afternoon (Time: 1 hour 35 minutes) | Paper Reference **WPH05/01** |
|---|---|

# Physics
## Advanced
## Unit 5: Physics from Creation to Collapse

| **You must have:** Ruler | 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.*
- You may use a scientific calculator.
- 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* ▶





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** What does background radiation consist of?

☒ **A** alpha radiation only

☒ **B** beta radiation only

☒ **C** gamma radiation only

☒ **D** alpha, beta and gamma radiation

**(Total for Question 1 = 1 mark)**

**2** Radioactivity is described as spontaneous and random.

Which row of the table states what is meant by spontaneous and random?

| | Spontaneous | Random |
|---|---|---|
| ☒ **A** | The decay process cannot be affected. | The next atom to decay cannot be predicted. |
| ☒ **B** | The time of the next decay cannot be predicted. | The decay process cannot be affected. |
| ☒ **C** | The next atom to decay cannot be predicted. | The type of radiation emitted at the next decay cannot be predicted. |
| ☒ **D** | The type of radiation emitted at the next decay cannot be predicted. | The time of the next decay cannot be predicted. |

**(Total for Question 2 = 1 mark)**

**3** Which of the following would **not** be an example of simple harmonic motion?

☒ **A** A mass bouncing on the end of a spring.

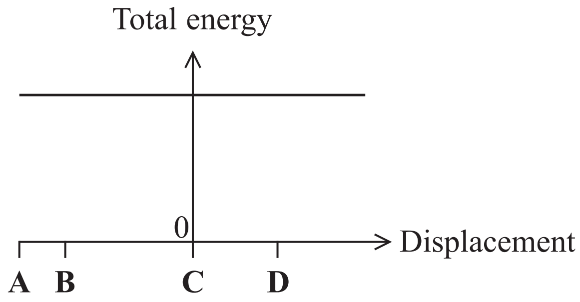
☒ **B** The vibrating prongs of a tuning fork.

☒ **C** A person jumping up and down on a trampoline.

☒ **D** The vibrations of a plucked string of a guitar.

**(Total for Question 3 = 1 mark)**

**4** The graph shows how the total energy varies with displacement for a particle undergoing undamped simple harmonic motion.




Which of the following displacements, A, B, C or D, corresponds to the position at which the kinetic energy is equal to the total energy?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 4 = 1 mark)**

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**5** The mass of Earth is $6.0 \times 10^{24}$ kg.

Which of the following expressions could be used to calculate the radius $r$ of the Earth?

☒ **A** $r = \dfrac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{9.81}$

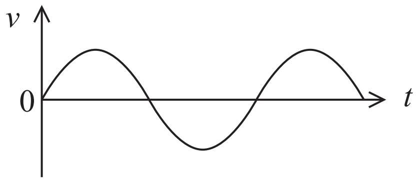
☒ **B** $r = \dfrac{9.81}{\sqrt{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}}$

☒ **C** $r = \sqrt{\dfrac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{9.81}}$

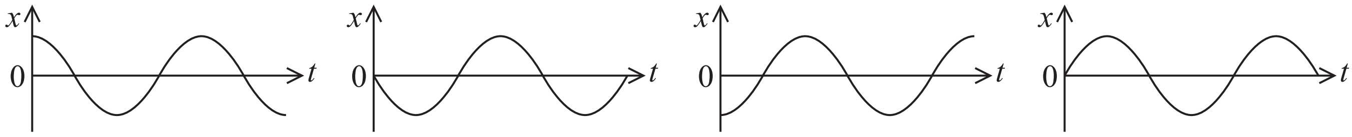
☒ **D** $r = \sqrt{\dfrac{9.81}{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}}$

**(Total for Question 5 = 1 mark)**

**6** The graph shows how the velocity $v$ varies with time $t$ for the motion of an object.




Which of the following graphs shows the variation of displacement $x$ with $t$ over the same time period?




☒ **A** ☒ **B** ☒ **C** ☒ **D**

**(Total for Question 6 = 1 mark)**

**7** The Sun has a radius $R$, surface temperature $T$ and luminosity $L$.

A white dwarf has a surface temperature $5T$ and luminosity $\frac{L}{16}$

Which of the following is the radius of the white dwarf in terms of $R$?

☒ **A** $\frac{R}{5}$

☒ **B** $\frac{R}{25}$

☒ **C** $\frac{R}{100}$

☒ **D** $\frac{R}{10\,000}$

**(Total for Question 7 = 1 mark)**

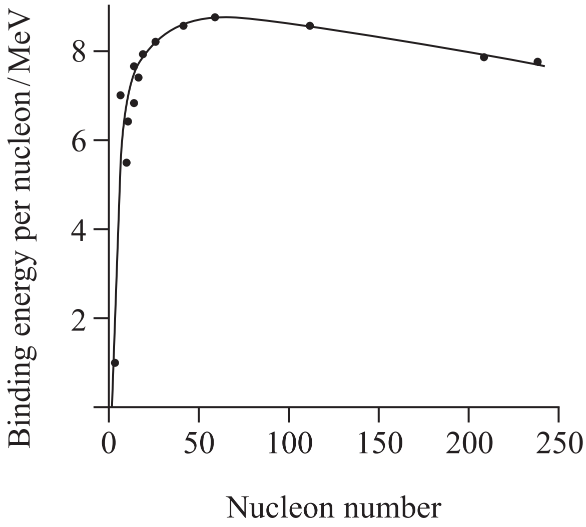
**8** Select the row of the table that gives a type of radiation and a possible use.

| | **Type** | **Use** |
|---|---|---|
| ☒ **A** | alpha radiation | image internal parts of the body |
| ☒ **B** | beta radiation | destroy cancer cells |
| ☒ **C** | gamma radiation | measure the thickness of paper |
| ☒ **D** | gamma radiation | remove static electricity |

**(Total for Question 8 = 1 mark)**

**Questions 9 and 10 refer to the following graph.**

The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.




**9** Which of the following gives the approximate energy, in MeV, released when a nucleus of ${}^{235}_{92}U$ undergoes fission?

- ☒ **A** 1 MeV
- ☒ **B** 8 MeV
- ☒ **C** 92 MeV
- ☒ **D** 235 MeV

**(Total for Question 9 = 1 mark)**

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**10** Which of the following is predicted by the graph?

- ☒ **A** Fission and fusion will produce radioactive products.
- ☒ **B** Energy can be released by the fusion of heavy nuclei.
- ☒ **C** Nuclei of nucleon number 50 are stable.
- ☒ **D** The mass deficit is largest for the fusion of light nuclei.

**(Total for Question 10 = 1 mark)**

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**TOTAL FOR SECTION A = 10 MARKS**

## SECTION B

**Answer ALL questions in the spaces provided.**

**11** Steel can be hardened by heating and then cooling it quickly. The cooling can be done by plunging the hot steel into a container of oil at room temperature.

(a) State what is meant by a hard material.

**(1)**

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(b) A steel bar of mass 0.40 kg and temperature 560 °C is plunged into oil of mass 4.4 kg and temperature 20 °C.

(i) Calculate the resulting temperature of the oil and steel.

specific heat capacity of steel = $450\,\mathrm{J\,kg^{-1}\,K^{-1}}$

specific heat capacity of oil = $1800\,\mathrm{J\,kg^{-1}\,K^{-1}}$

**(3)**

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Temperature = ..............................................

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(ii) The final temperature of the oil and steel was not the same as the value calculated in (b)(i). Explain two reasons why.

**(4)**

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**(Total for Question 11 = 8 marks)**

**12** A sound wave can be used to mix materials together efficiently in a process known as resonant acoustic mixing.

(a) A sound wave of frequency 60 Hz is applied to a container to mix tiny particles and a liquid. During the process, the movement of the tiny particles is approximately simple harmonic motion.

The maximum acceleration of these particles is $100 \times g$.

(i) Calculate the amplitude of the oscillations of the tiny particles.

**(3)**

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Amplitude = .......................................................

(ii) When the sound wave is switched off, the amplitude of vibration of the particles reduces rapidly.

Explain this observation.

**(2)**

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*(b) At a frequency of 60 Hz, resonance occurs.

Explain what is meant by resonance.

**(3)**

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**(Total for Question 12 = 8 marks)**

**13** All objects with a temperature above absolute zero emit a spectrum of electromagnetic radiation.

(a) Wien's law relates the temperature of an object to the wavelength at which peak power emission occurs.

(i) State one assumption that must be made about the object for this law to be applied.

**(1)**

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(ii) The filament of a reading lamp reaches a temperature of 2200 K when operating normally.

The efficiency of the lamp is related to the power of the visible light radiated.

Explain why the efficiency of this lamp has a very low value.

Your answer should include a calculation.

**(3)**

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(b) A room is illuminated by a 100 W filament lamp.

Calculate the radiation flux at a distance of 3.0 m from the lamp.

efficiency of lamp = 5.0%

**(3)**

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Radiation flux = ..........................................

**(Total for Question 13 = 7 marks)**

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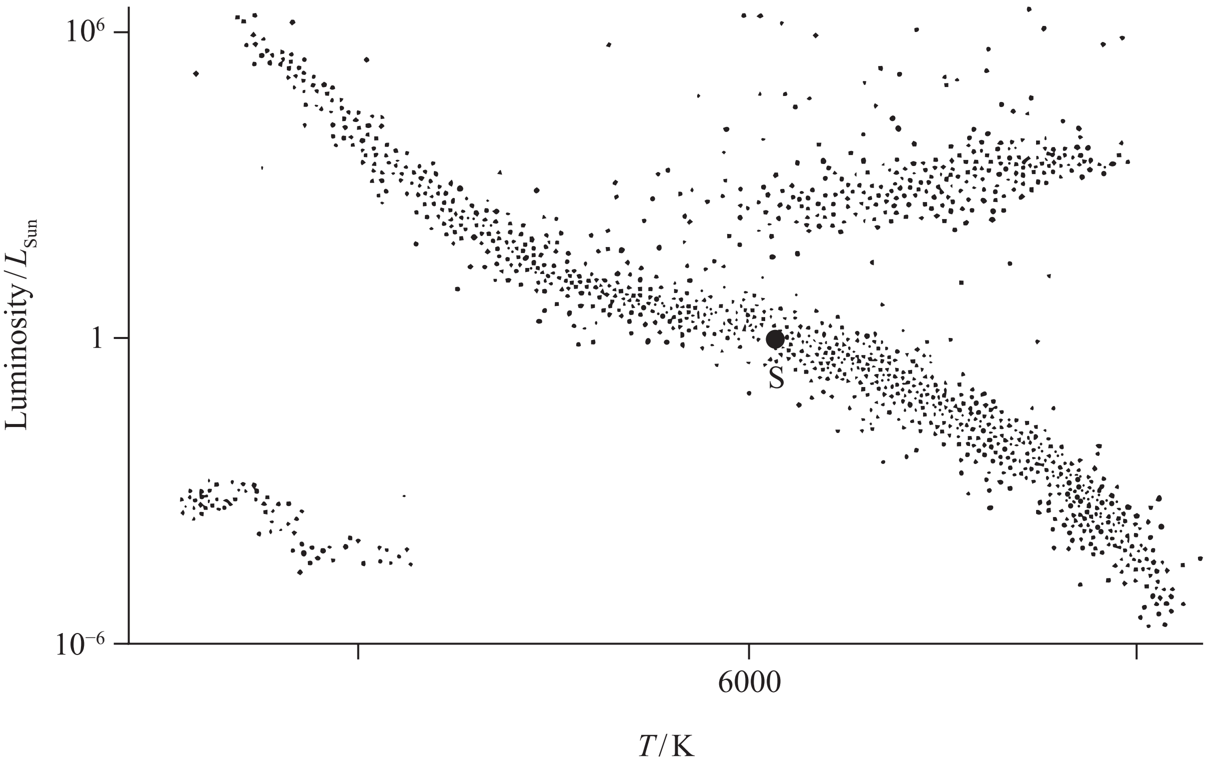
**14** A binary star system consists of two main sequence stars; a large white-blue star W and a smaller yellow-orange star Y. They orbit around a common centre of mass.

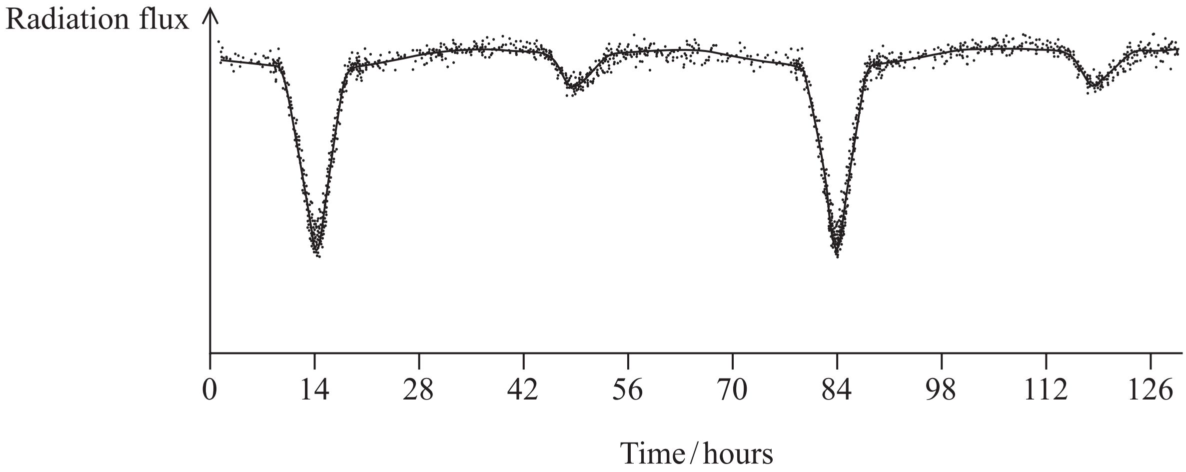
(a) The Hertzsprung-Russell diagram shows a large number of stars, including our Sun S.




(i) Add two temperatures to the horizontal axis to indicate the scale. **(2)**

(ii) Add to the diagram to show the approximate positions of W and Y. **(2)**

(b) The radiation flux from this binary star system was monitored for several days using a sensor connected to a data logger. The graph shows part of the output from the data logger.




(i) The diagram below shows four positions, A, B, C and D, of stars W and Y during their orbit, as viewed from Earth.


Explain how the radiation flux varies as the stars move through positions A, B, C and D. You should make reference to the graph of radiation flux against time.

**(3)**

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(ii) The radius of orbit of star Y is $7.6 \times 10^9$ m.

(1) Show that the velocity of star Y is about $2 \times 10^5\, m\, s^{-1}$.

**(3)**

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(2) The distance between the centres of star W and star Y is $9.3 \times 10^9$ m.

Show that the mass of star W is about three times that of the Sun.

mass of Sun = $2.0 \times 10^{30}$ kg

**(3)**

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**(Total for Question 14 = 13 marks)**

**15** (a) Describe how the distance to galaxies can be determined using a knowledge of standard candles.

**(3)**

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*(b) Describe how the recessional velocity of galaxies can be determined.

**(3)**

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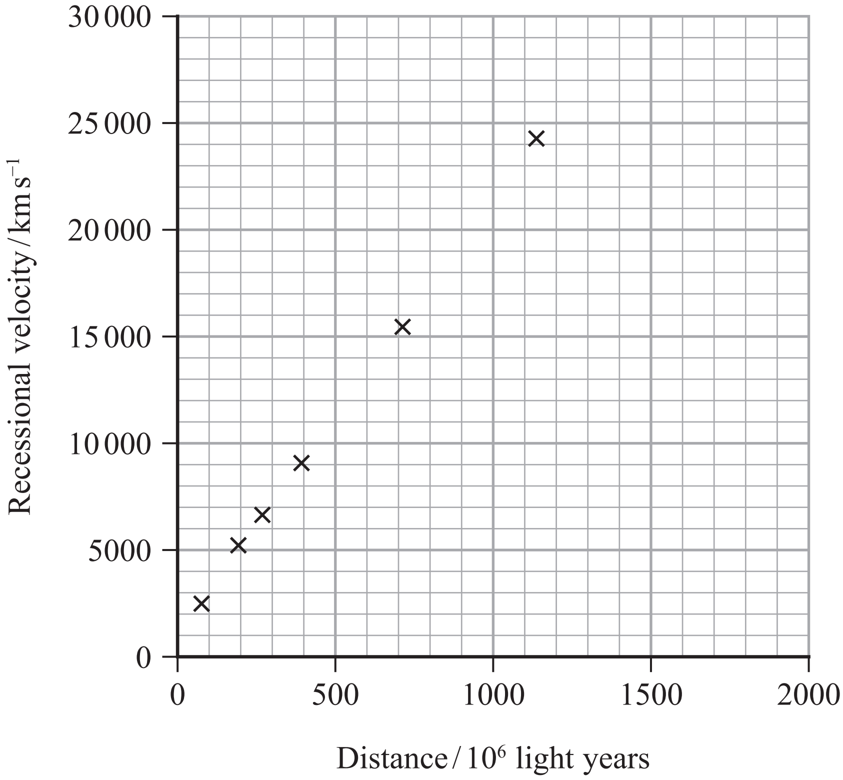
(c) The graph shows how the recessional velocity for a number of distant galaxies varies with their distance from Earth.




(i) Determine a value for the Hubble constant in $s^{-1}$.

1 year = $3.15 \times 10^7$ s

**(4)**

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Hubble constant = ........................................................ $s^{-1}$

(ii) Explain how this graph leads to the idea that the universe is expanding uniformly.

**(4)**

(d) Explain the consequence of the existence of dark matter for the ultimate fate of the universe.

**(2)**

**(Total for Question 15 = 16 marks)**

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**16** An expansion cloud chamber can be used to study particle tracks. The cloud chamber shown in the photograph consists of a closed glass cylinder that contains a radioactive source and air at a temperature of 293 K.


(Source: © PAL)

The cylinder has a radius of 60 mm and a height of 28 mm.

(a) (i) Show that the number of molecules of air within the cylinder is about $8 \times 10^{21}$

Assume air is an ideal gas.

air pressure = $1.0 \times 10^5$ Pa

**(3)**

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(ii) A bicycle pump is connected to the chamber to remove some of the air. When the pump handle is pulled out quickly, 20% of the air in the chamber is removed and the internal energy of the remaining air is reduced by 6.3 J.

Calculate the final temperature of the air.

**(4)**

Final temperature = ..................................................

*(b) When the temperature in the chamber is reduced, it enables the tracks of particles to be seen as trails of vapour droplets. The photograph shows the tracks of alpha particles emitted by the source.

The photograph is actual size.

Explain the properties of alpha particles that can be deduced from this photograph.

**(4)**

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(c) The alpha particles were produced by a radium $^{226}_{88}Ra$ source which has a half life of 1600 years.

Calculate the activity of the source after 10 years.

The initial activity of the source was 3700 Bq.

**(3)**

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Activity = ..............................................

(d) A nucleus of radium Ra decays into a nucleus of radon Rn.

Calculate the energy released, in MeV, for this decay.

mass of $^{226}_{88}Ra$ = 226.025402 u

mass of $^{222}_{86}Rn$ = 222.017570 u

mass of $^{4}_{2}He$ = 4.002600 u

**(4)**

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Energy released = .............................................. MeV

**(Total for Question 16 = 18 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 | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| Forces | $\Sigma F = ma$<br>$g = F/m$<br>$W = mg$ |
| Work and energy | $\Delta W = F\Delta s$<br>$E_k = \frac{1}{2}mv^2$<br>$\Delta E_{grav} = mg\Delta h$ |

*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<br>Stress $\sigma = F/A$<br>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 | $P = VI$<br>$P = I^2R$<br>$P = V^2/R$<br>$W = VIt$ |
| | $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ |
| | $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$ |
| Resistivity | $R = \rho l/A$ |
| Current | $I = \Delta Q/\Delta t$<br>$I = nqvA$ |
| 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 | $v = \omega r$<br>$T = 2\pi/\omega$<br>$F = ma = mv^2/r$<br>$a = v^2/r$<br>$a = r\omega^2$ |

*Fields*

| | |
|---|---|
| Coulomb's law | $F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$ |
| Electric field | $E = F/Q$<br>$E = kQ/r^2$<br>$E = V/d$ |
| 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 | $F = BIl \sin\theta$<br>$F = Bqv \sin\theta$<br>$r = p/BQ$ |
| 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 | $\mathrm{d}N/\mathrm{d}t = -\lambda N$ |
| | $\lambda = \ln 2/t_{½}$ |
| | $N = N_0 e^{-\lambda t}$ |

*Mechanics*

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

*Observing the universe*

| | |
|---|---|
| Radiant energy flux | $F = L/4\pi d^2$ |
| Stefan-Boltzmann law | $L = \sigma T^4 A$<br>$L = 4\pi r^2 \sigma T^4$ |
| 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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