BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2016 HIGHER SCHOOL CERTIFICATE EXAMINATION

IMPORTANT:
This resource was developed to support a previous version of the syllabus. It may contain content that differs from the current syllabus.

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper

Total marks – 100

Section I Pages 2–28

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21–30
- Allow about 1 hour and 40 minutes for this part

Section II Pages 29–37

25 marks

- Attempt ONE question from Questions 31–35
- Allow about 45 minutes for this section

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1–20.

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1 Some mobile phones are recharged at a power point using a charger that contains a transformer.

What is the purpose of the transformer?

(A) To convert AC at the power point to DC

(B) To convert DC at the power point to AC

(C) To increase the AC voltage at the power point

(D) To decrease the AC voltage at the power point

2 Both Westinghouse and Edison proposed methods for supplying electricity to homes.

What advantage did Westinghouse's method have over Edison's?

(A) DC could be supplied at a lower current, making it safer for the consumer.

(B) DC could be supplied at a lower voltage, making it safer for the consumer.

(C) AC allowed for the use of a lower transmission current, reducing energy losses.

(D) AC allowed for the use of a lower transmission voltage, reducing energy losses.

3 A region of space contains a constant magnetic field and a constant electric field.

How will these fields affect an electron that is stationary in this region?

(A) Both fields will exert a force.

(B) Neither field will exert a force.

(C) Only the electric field will exert a force.

(D) Only the magnetic field will exert a force.

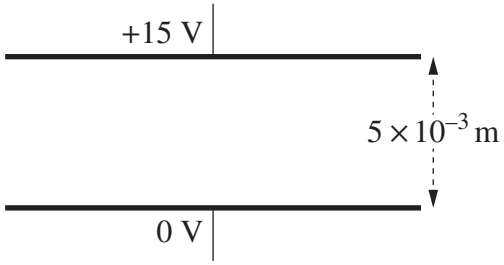
4 The graph shows information about three superconductors *X*, *Y* and *Z* including their year of discovery.



Which row of the table correctly classifies *X*, *Y* and *Z*?

	X	*Y*	*Z*
(A)	Metal	Metal alloy	Compound
(B)	Metal	Compound	Metal alloy
(C)	Metal alloy	Metal	Compound
(D)	Metal alloy	Compound	Metal

5 The diagram shows two parallel charged plates 5×10^{-3} m apart.



What is the magnitude of the electric field between the plates in V m^{-1}?

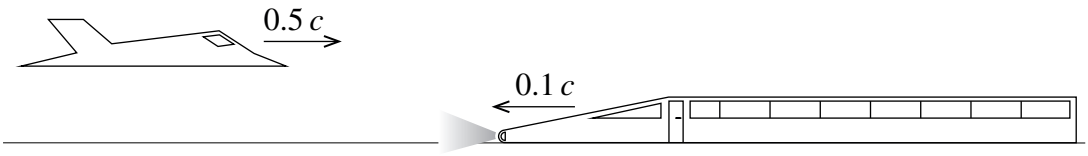
(A) 3.3×10^{-4}

(B) 0.33

(C) 3

(D) 3000

6 In a thought experiment, a jet is travelling at 0.5 c relative to the ground, towards a train that is travelling at 0.1 c relative to the ground, as shown.



What is the speed of the light emitted from the train's headlight, as measured by a pilot in the jet?

(A) 0.1 c

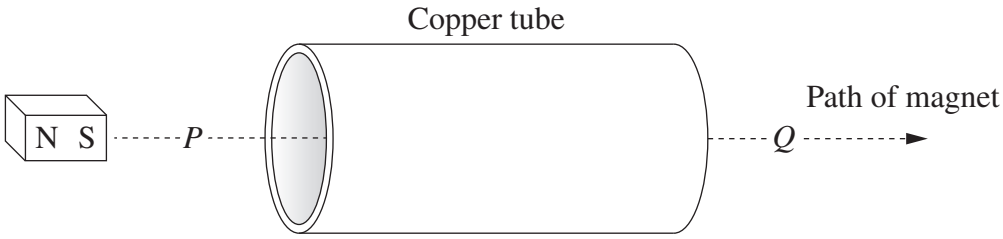
(B) 0.4 c

(C) 0.6 c

(D) 1.0 c

7 A magnet passes through a copper tube at constant velocity along the path shown.

A current is induced in the tube by the motion of the magnet.

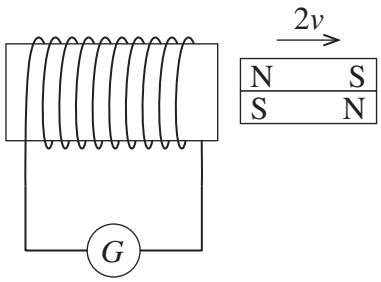


Which row of the table correctly describes the forces acting between the tube and the magnet at points P and Q?

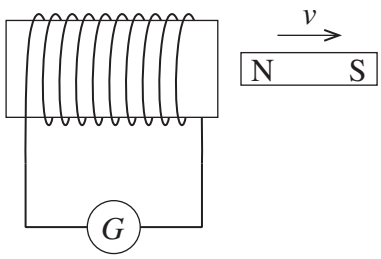
	Force at P	*Force at Q*
(A)	Attraction	Repulsion
(B)	Repulsion	Attraction
(C)	Attraction	Attraction
(D)	Repulsion	Repulsion

8 Which movement of the magnet(s) will produce the greatest deflection of the galvanometer?

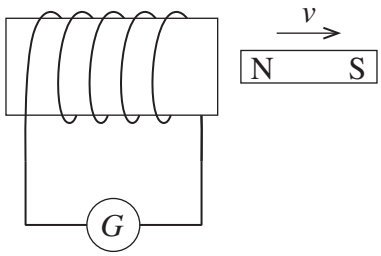
(A)



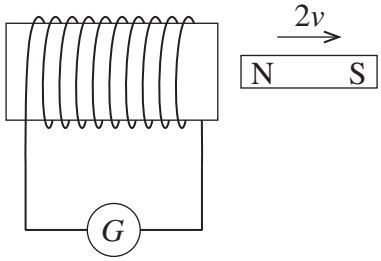
(B)



(C)



(D)



9 How does back emf affect a DC motor?

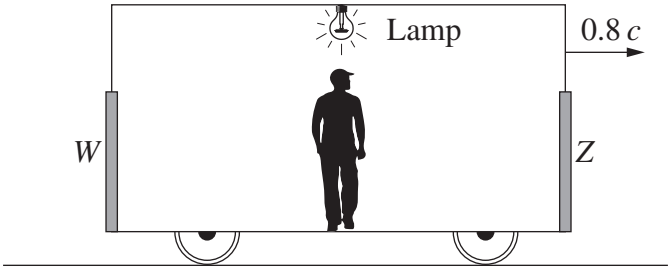
(A) It creates heat in the iron core.

(B) It limits the speed of the motor.

(C) It reverses the current in the coil.

(D) It increases the torque of the motor.

10 In a thought experiment, a train is moving at a constant speed of 0.8 c. A lamp is located at the midpoint of a carriage. There are doors W and Z at each end of the carriage which open automatically when light from the lamp reaches them.



The passenger standing at the midpoint of the carriage switches on the lamp.

Which statement best explains what the passenger observes about the doors?

(A) Z opens before W because the lamp is moving towards Z.

(B) W opens before Z because W is moving towards the lamp.

(C) W and Z open simultaneously because the lamp is placed at an equal distance from both.

(D) W and Z open simultaneously because the distance from the lamp to each door has contracted by the same amount.

11 What is the wavelength, in metres, of a photon with an energy of 3.5 eV?

(A) 1.2×10^{-6}

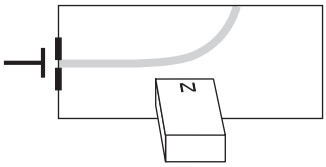
(B) 3.5×10^{-7}

(C) 1.18×10^{-15}

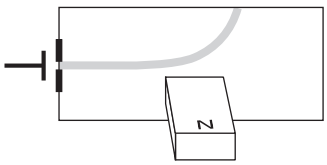
(D) 5.67×10^{-26}

12 Which diagram correctly shows the deflection of a cathode ray by a bar magnet?

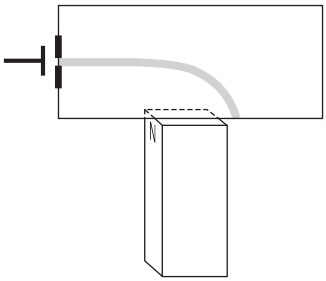
(A)



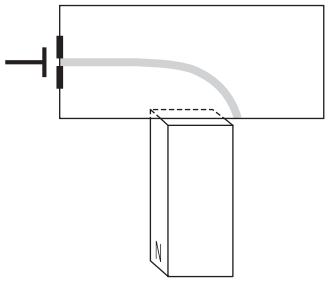
(B)



(C)



(D)

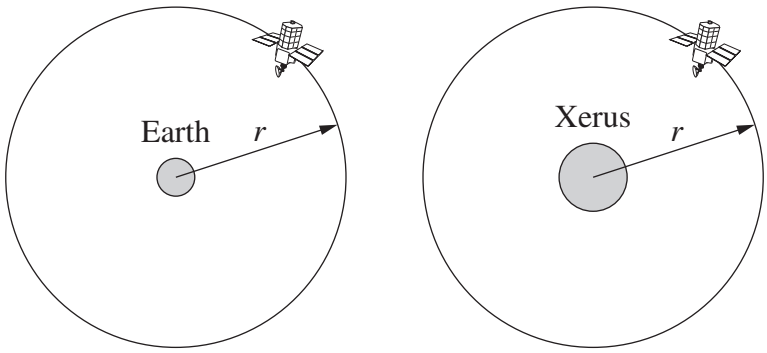


13 When light of a specific frequency strikes a metal surface, photoelectrons are emitted.

If the light intensity is increased but the frequency remains the same, which row of the table is correct?

	Number of photoelectrons emitted	*Maximum kinetic energy of the photoelectrons*
(A)	Remains the same	Remains the same
(B)	Remains the same	Increases
(C)	Increases	Remains the same
(D)	Increases	Increases

14 A satellite orbits Earth with period T. An identical satellite orbits the planet Xerus which has a mass four times that of Earth. Both satellites have the same orbital radius r.



What is the period of the satellite orbiting Xerus?

(A) $\frac{T}{4}$

(B) $\frac{T}{2}$

(C) $2T$

(D) $4T$

15 Which of the following statements correctly describes the effect of light in a solar cell?

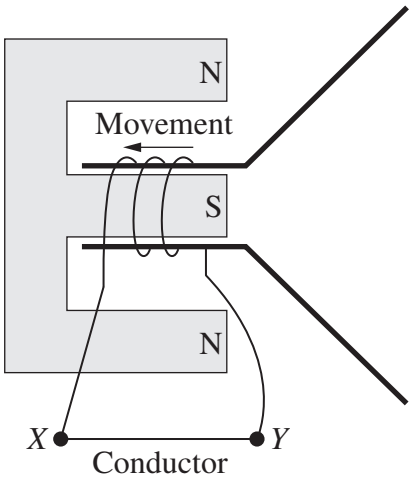
(A) The light produces electron-hole pairs.

(B) The light causes pure silicon to become *n*-type silicon.

(C) The light increases the potential difference across the *p*-*n* boundary.

(D) The light transfers energy to electrons in the conduction band of the *p*-type semiconductor.

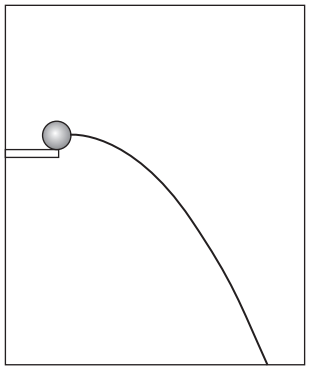
16 The cone of a speaker is pushed so that the coil moves in the direction shown.



Which row of the table correctly identifies the behaviour of the speaker and the direction of the current through the conductor?

	The speaker behaves like a …	*The direction of the current is from …*
(A)	generator	*X* to *Y*
(B)	generator	*Y* to *X*
(C)	motor	*X* to *Y*
(D)	motor	*Y* to *X*

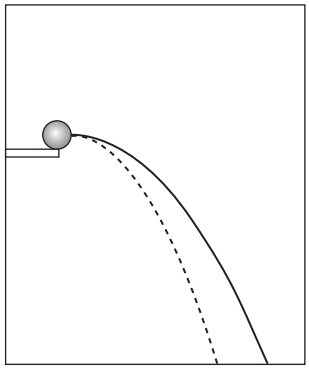
17 A projectile was launched horizontally inside a lift in a building. The diagram shows the path of the projectile when the lift was stationary.



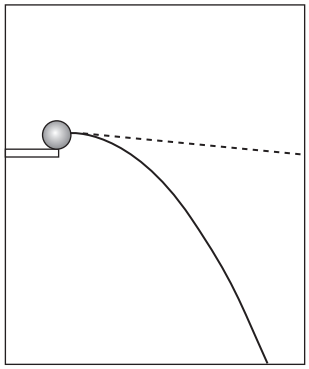
The projectile was launched again with the same velocity. At this time, the lift was slowing down as it approached the top floor of the building.

Which diagram correctly shows the new path of the projectile (dotted line) relative to the path created in the stationary lift (solid line)?

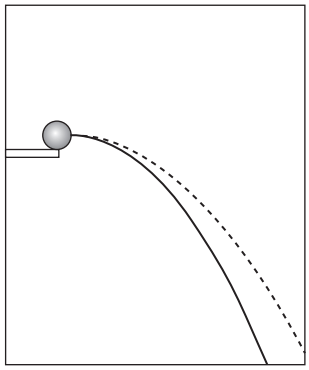
(A)



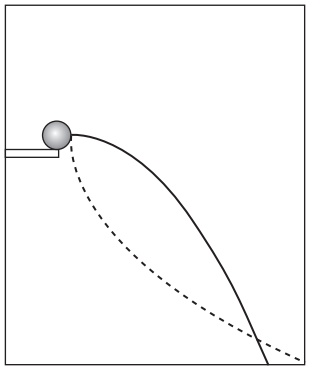
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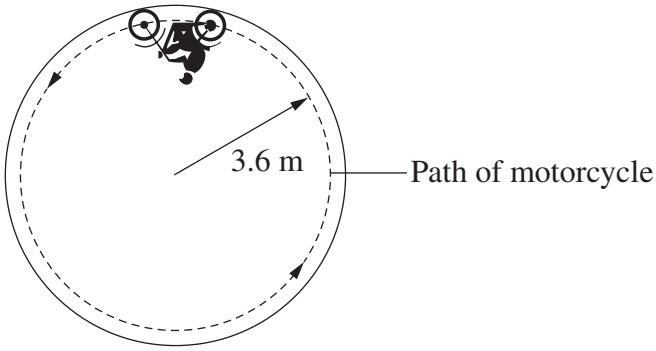
(C)



(D)



18 A motorcycle travels around a vertical circular path of radius 3.6 m at a constant speed. The combined mass of the rider and motorcycle is 200 kg.



What is the minimum speed, in m s^{-1}, at which the motorcycle must travel to maintain the circular path?

(A) 0.42

(B) 1.9

(C) 5.9

(D) 35

19 Muons are subatomic particles which at rest have a lifetime of 2.2 microseconds (μs). When they are produced in Earth's upper atmosphere, they travel at 0.9999 c.

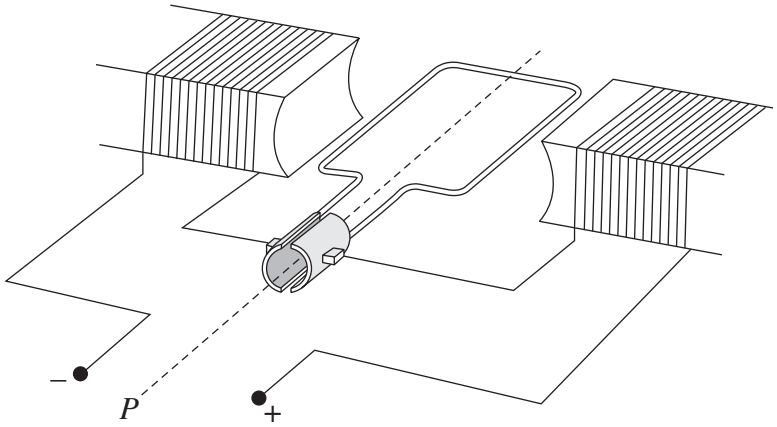
Using classical physics, the distance travelled by a muon in its lifetime can be calculated as follows:

$$x = vt$$
$$= 660 \text{ m}$$

Which row of the table correctly summarises the behaviour of these muons?

	Muon's reference frame		Earth's reference frame	
	Distance travelled (m)	*Lifetime* (μs)	*Distance travelled* (m)	*Lifetime* (μs)
(A)	660	2.2	> 660	> 2.2
(B)	> 660	> 2.2	660	2.2
(C)	660	2.2	< 660	< 2.2
(D)	< 660	< 2.2	660	2.2

20 In the motor shown, the rotor spins clockwise, as viewed from point *P*, when connected to a DC supply.



What happens when the motor is connected to an AC supply?

(A) There is no movement of the rotor.

(B) The rotor produces clockwise movement only.

(C) The rotor vibrates at the frequency of the AC supply.

(D) The rotor continuously turns half a rotation clockwise, then half a rotation anticlockwise.

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Physics

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing space is provided on pages 27 and 28. If you use this space, clearly indicate which question you are answering.

Write your Centre Number and Student Number at the top of this page.

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Question 21 (5 marks)

(a) Why does orbital decay occur more rapidly for satellites in a low-Earth orbit than for satellites in other orbits? **2**

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(b) Calculate the magnitude of the gravitational force that acts on a 50 kg satellite when it is 8000 km from Earth's centre. **3**

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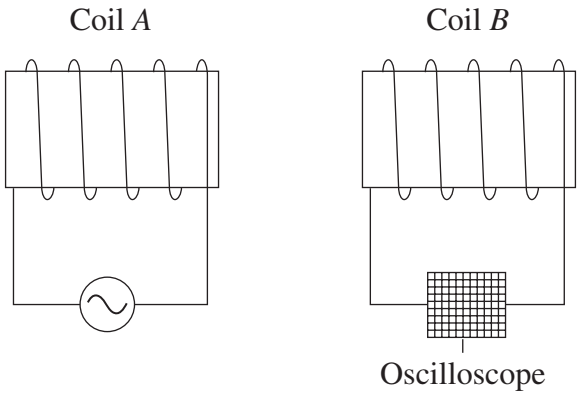
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Question 22 (6 marks)

(a) When an alternating current is passed through coil *A,* a voltage is observed on the oscilloscope connected to coil *B*. **2**



How could a bar magnet be used, instead of coil *A*, to produce a similar pattern on the oscilloscope?

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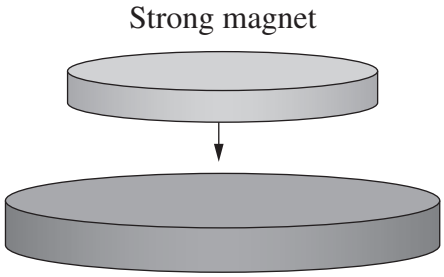
Question 22 continues on page 17

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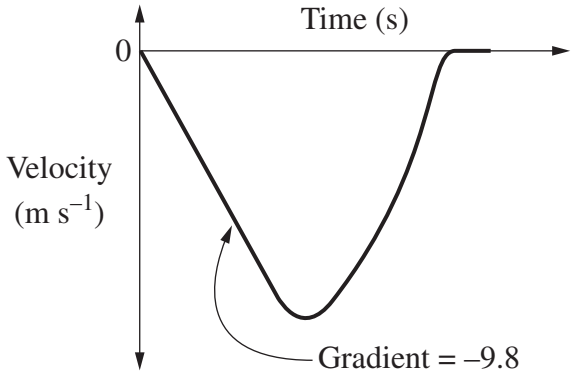
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Question 22 (continued)

(b) A strong magnet is at rest a few centimetres above a solid metal disc made of a non-magnetic metal. The magnet is then dropped. **4**



The velocity of the magnet is shown in this graph.



Account for the shape of the graph.

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End of Question 22

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Question 23 (6 marks)

(a) Explain the role of the deflection plates in displaying voltage changes applied to the input of a cathode ray oscilloscope. **3**

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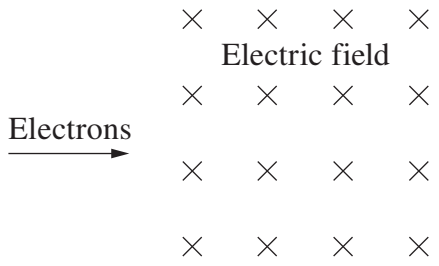
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(b) The diagram shows electrons travelling in a vacuum at 5.2×10^4 m s^{-1} entering an electric field of 10 V m^{-1}. **3**



A magnetic field is applied so that the electrons continue undeflected.

What is the magnitude and direction of the magnetic field?

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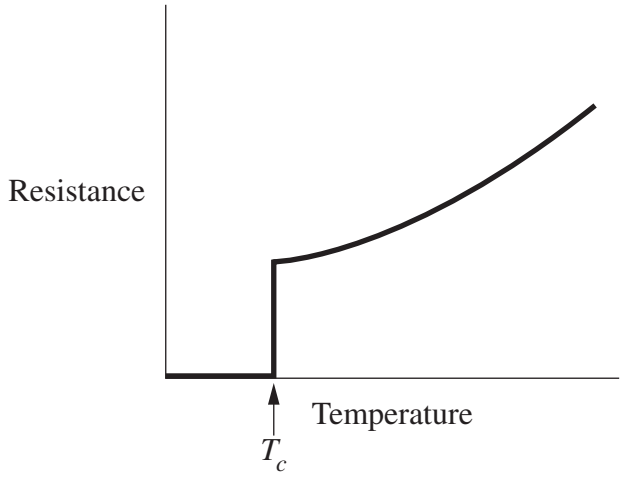
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Question 24 (4 marks)

The graph shows the effect of temperature on the resistance of a metal wire. **4**



Explain the shape of this graph in terms of the behaviour of electrons in the metal, both above and below the critical temperature (T_c).

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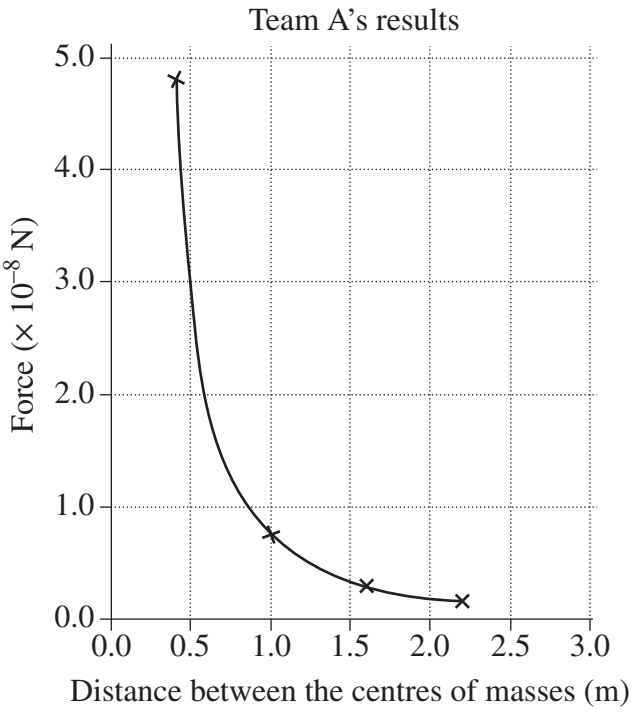
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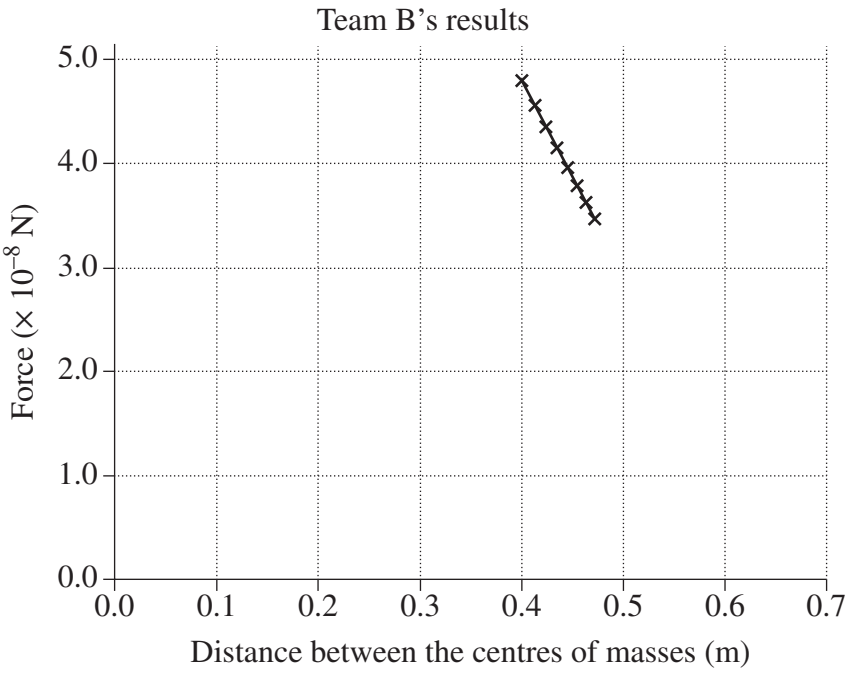
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Question 25 (5 marks)

Two teams carried out independent experiments with the purpose of investigating Newton's Law of Universal Gravitation. Each team used the same procedure to accurately measure the gravitational force acting between two spherical masses over a range of distances.

The following graphs show the data collected by each team.





Question 25 continues on page 21

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Question 25 (continued)

(a) Compare qualitatively the relationship between force and distance in the graphs. **2**

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(b) Assess the appropriateness of Team A's data and Team B's data in achieving the purpose of the experiments. **3**

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End of Question 25

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Question 26 (5 marks)

Explain how applications of transformers have affected society. **5**

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Question 27 (7 marks)

(a) Outline observations that Hertz made that were consistent with the photoelectric effect. In your answer, identify equipment that was essential for him to make these observations. **3**

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(b) Explain how the result of ONE investigation of the photoelectric effect changed the scientific understanding of the nature of light. **4**

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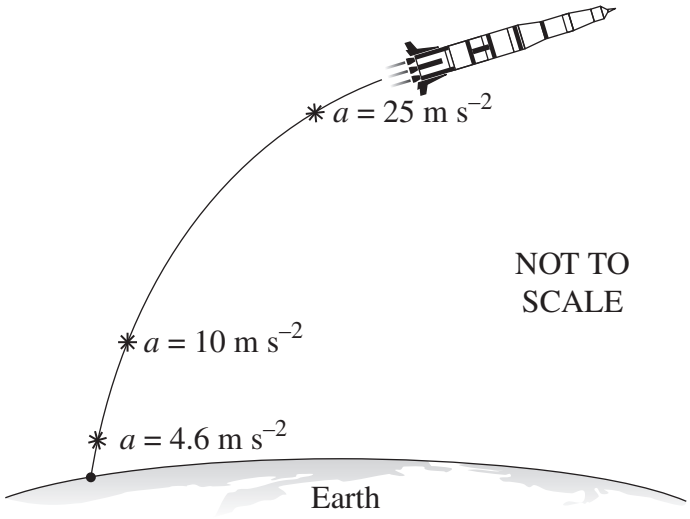
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Question 28 (5 marks)

The following diagram shows the acceleration of a rocket during the first stage of its launch. **5**



Explain the acceleration of the rocket with reference to the law of conservation of momentum.

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Question 29 (6 marks)

Explain how different discoveries in physics led to the development of THREE technologies, including the electric generator. **6**

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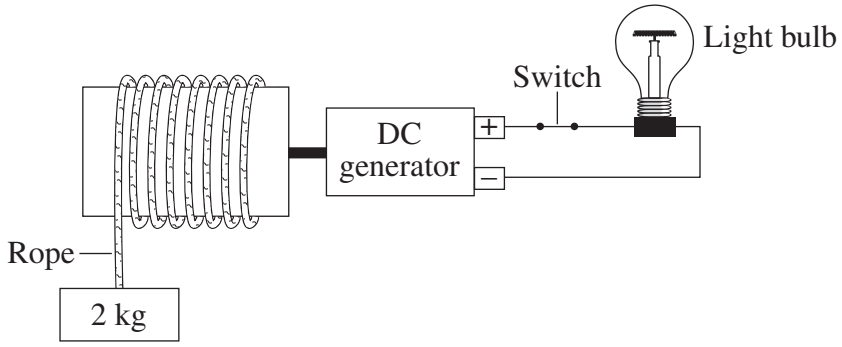
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Question 30 (6 marks)

The following makeshift device was made to provide lighting for a stranded astronaut on Mars.

The mass of Mars is 6.39×10^{23} kg.



The 2 kg mass falls, turning the DC generator, which supplies energy to the light bulb. The mass falls from a point that is 3 376 204 m from the centre of Mars.

(a) Calculate the maximum possible energy released by the light bulb as the mass falls through a distance of one metre. **3**

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(b) Explain the difference in the behaviour of the falling mass when the switch is open. **3**

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Section I Part B extra writing space

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Physics

Section II

25 marks
Attempt ONE question from Questions 31–35
Allow about 45 minutes for this section

Answer parts (a)–(e) of one question in the Section II Writing Booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Pages

Question 31 Geophysics 30–31

Question 32 Medical Physics 32

Question 33 Astrophysics 33

Question 34 From Quanta to Quarks 34

Question 35 The Age of Silicon 35–37

Question 31 — Geophysics (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) What role do geophysicists play in the monitoring of the nuclear test ban treaties? **2**

(ii) Explain how ONE geophysical method used in mineral exploration can produce an economic benefit. **3**

(b) (i) Describe a model that shows the relationship between the inclination of Earth's magnetic field and latitude. **3**

(ii) Describe features of Earth's magnetic field, other than the variation of its inclination with latitude. **3**

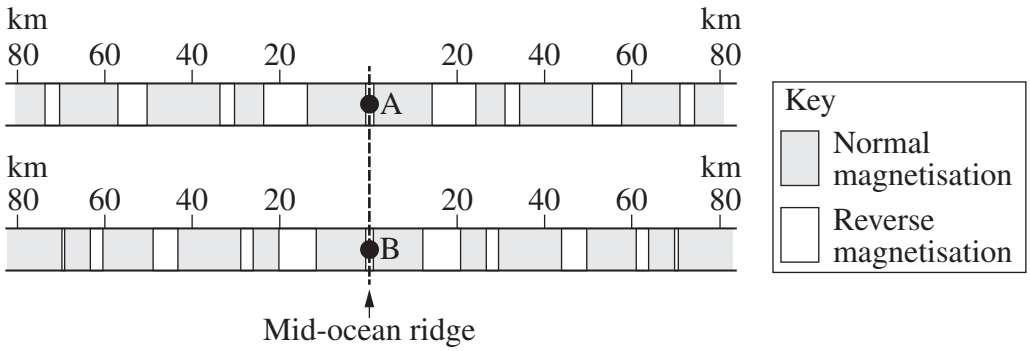
(c) Explain TWO corrections that must be made when gravimeter data is being analysed. **4**

Question 31 continues on page 31

Question 31 (continued)

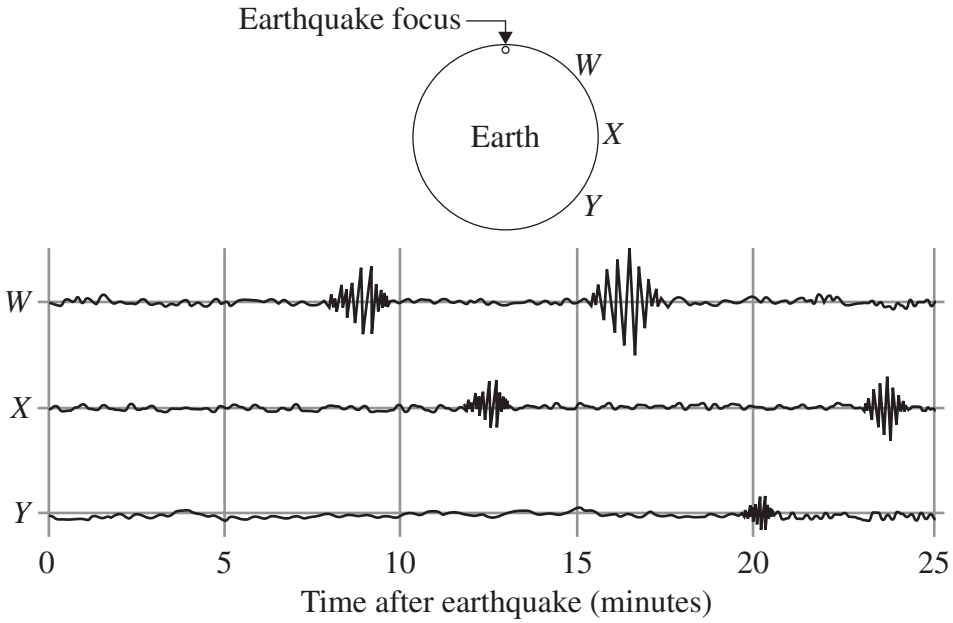
Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) The diagram shows the magnetisation of rocks along lines perpendicular to the same mid-ocean ridge, from locations A and B. **4**



What valid inferences can be made from these data sets? Justify your answer.

(e) After an earthquake, the following seismograms were obtained from stations *W*, *X* and *Y* on Earth's surface. **6**



Relate features on the seismograms to the behaviour of different types of earthquake waves and Earth's internal structure.

End of Question 31

Question 32 — Medical Physics (25 marks)

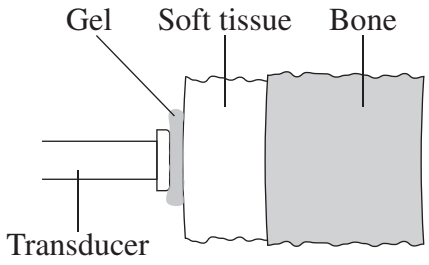
Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) What are the differences between hard and soft X-rays? **2**

(ii) Account for the widespread use of X-rays to create images of human limbs. **3**

(b) (i) Describe the piezoelectric effect and its application in ultrasound imaging. **3**

(ii) An ultrasound pulse leaves the transducer and passes from the gel through soft tissue and bone as shown. A table of acoustic impedances is provided. **3**



Medium	*Acoustic impedance* (kg m^{-2} s^{-1})
Gel	1.632×10^6
Soft tissue	1.632×10^6
Bone	6.732×10^6

Describe what happens to the intensity of the ultrasound pulse at each boundary. Use calculations to support your answer.

(c) Contrast the use of Doppler ultrasound imaging with the use of computed axial tomography (CAT) imaging. In your answer, include an example of how each is used. **4**

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Describe how positron emission tomography (PET) scanning is used in diagnosis. In your answer, refer to the interaction of positrons and electrons. **4**

(e) Explain how principles of physics are applied in magnetic resonance imaging (MRI). **6**

Question 33 — Astrophysics (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Distinguish between the terms *resolution* and *sensitivity* as applied to optical telescopes. **2**

(ii) Outline ways of improving the resolution of ground-based telescopes. **3**

(b) (i) Explain how trigonometric parallax is used to determine the distance to a star. **3**

(ii) Determine the absolute magnitude of a star which has an apparent magnitude of 4.2 and a parallax of 0.055 arc seconds. **3**

(c) Describe how the spectrum of a star can be used to determine its chemical composition and surface temperature. **4**

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Explain how the study of different types of variable stars has increased our understanding of celestial objects. **4**

(e) Describe how the distribution of stars on a Hertzsprung–Russell diagram relates to the processes that occur during their evolution. **6**

Question 34 — From Quanta to Quarks (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Identify the TWO types of nucleon and state ONE difference between them. **2**

(ii) Explain the stability of $^{4}_{2}He$ nuclei in terms of TWO forces. **3**

(b) (i) Outline features of the hydrogen spectrum that Bohr's model could not explain. **3**

(ii) Calculate the initial energy level of an electron in a hydrogen atom if it emitted 4.089×10^{-19} J on transition to the $n = 2$ level. **3**

(c) Describe how contributions to atomic theory made by Pauli and Heisenberg changed Bohr's model of the atom. **4**

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Explain how evidence from experiments involving particle accelerators and detectors has provided support for the standard model of matter. **4**

(e) How did Fermi's work in nuclear physics lead to applications that have affected society? **6**

Question 35 — The Age of Silicon (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Use sketches to show how analogue and digital voltage outputs are different. **2**

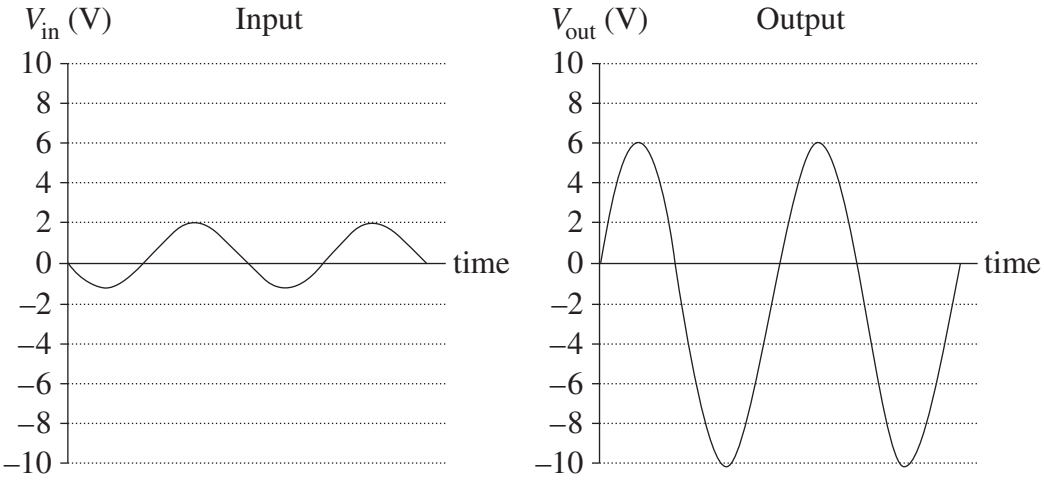
(ii) Describe ONE advantage of electronic circuits and ONE advantage of electric circuits. **3**

(b) (i) The table shows properties of a real operational amplifier. **3**

Voltage gain	200 000
Input impedance	2 MΩ
Output resistance	100 Ω
Bandwidth	0–1 MHz

How do these properties compare with those of an ideal amplifier?

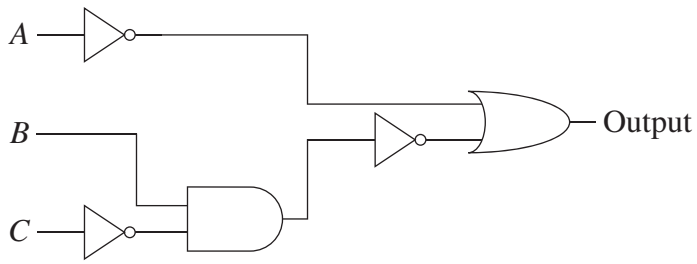
(ii) An inverting amplifier is constructed using a single operational amplifier and two resistors. The input resistor has a value of 2.2 kΩ. The graphs show input and output voltages for the circuit of this amplifier over the same time interval. **3**



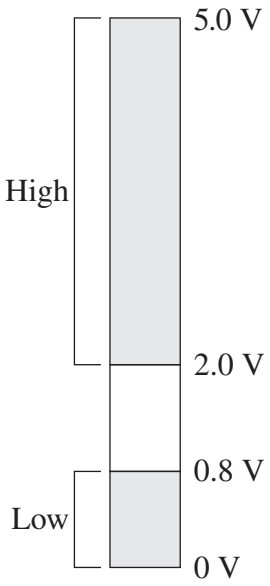
Draw a diagram of this circuit, showing the value of each resistor.

Question 35 continues on page 36

(c) The logic circuit shown was constructed using a number of components. **4**



The diagram shows acceptable input voltages for these components.



A low voltage output is required from the circuit.

Determine possible input voltages for *A*, *B* and *C*. Support your answer using a truth table.

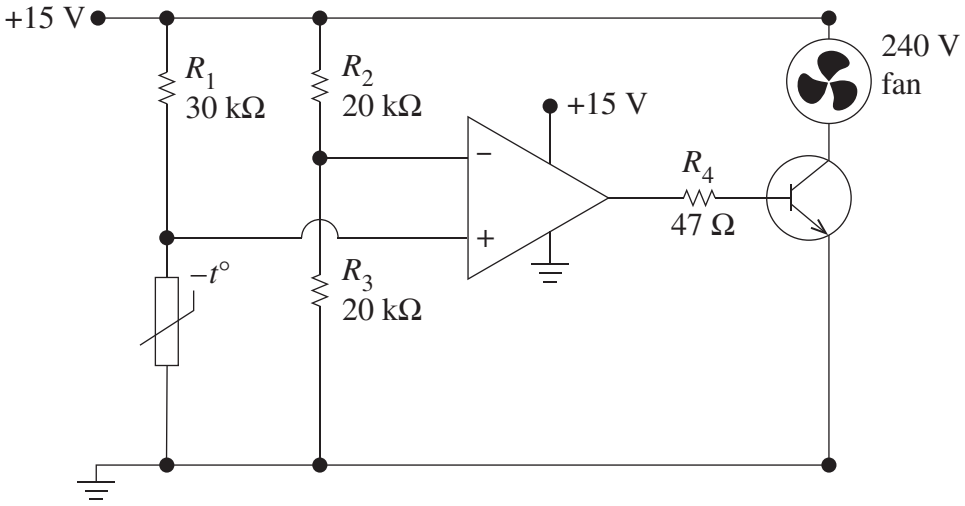
Question 35 continues on page 37

Question 35 (continued)

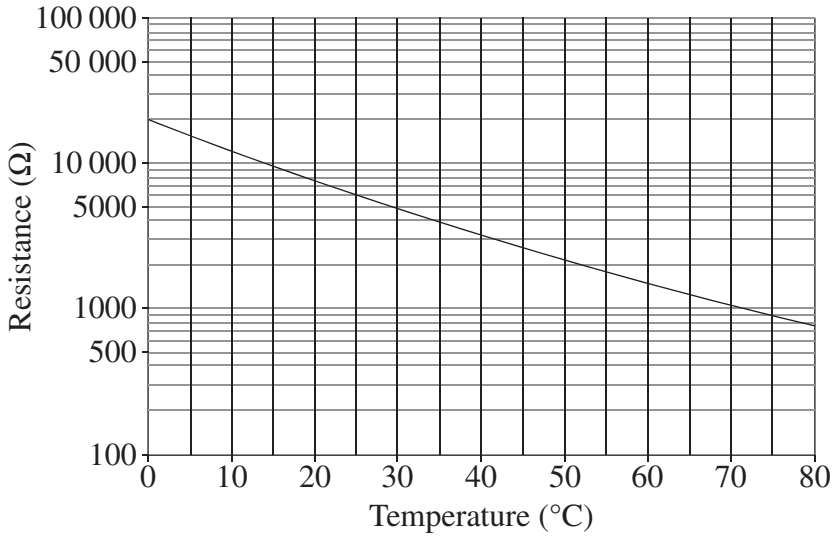
Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Explain the advantages of using integrated circuits instead of individual transistors in electronic devices. **4**

(e) A circuit is required to automatically switch on a 240 V fan when the temperature exceeds 30°C. The circuit shown was designed by a student but does not operate as intended. **6**



The graph shows the characteristic curve of the thermistor in the circuit.



Explain THREE changes that need to be made for this circuit to operate correctly.

End of paper

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Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{\text{av}} = \frac{\Delta r}{\Delta t}$$

$$a_{\text{av}} = \frac{\Delta v}{\Delta t} \quad \text{therefore} \quad a_{\text{av}} = \frac{v - u}{t}$$

$$\Sigma F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y \Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \tfrac{1}{2}a_y t^2$$

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

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{\left(m_B - m_A\right)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Uut Ununtrium	114 Fl Flerovium	115 Uup Ununpentium	116 Lv Livermorium	117 Uus Ununseptium	118 Uuo Ununoctium

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (January 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.