2023 HSC Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

Question	Answer
1	D
2	C
3	C
4	B
5	D
6	D
7	C
8	B
9	A
10	D
11	A
12	B
13	C
14	C
15	A
16	C
17	B
18	A
19	B
20	D

Section II

Question 21 (a)

Criteria	Marks
• Identifies TWO variables that determine the luminosity of a star	2
• Identifies ONE variable that determines the luminosity of a star	1

Sample answer:

The luminosity of a star is determined by the size and temperature of the star.

Answers could include:

- Star colour
- Mass of a star
- Surface area of a star
- Power output of the star

Question 21 (b)

Criteria	Marks
• Describes differences between Star *A* and Star *B*	3
• Identifies features of Star *A* and/or Star *B*	2
• Provides some relevant information	1

Sample answer:

Star *A* is a main sequence star and is fusing hydrogen into helium, whereas no nuclear reactions are taking place in Star *B* which is a white dwarf. Star *A* has a greater luminosity than Star *B*.

Answers could include:

- Radius
- Composition
- Mass

Question 22

Criteria	Marks
• Calculates the time between the pulses, relative to an observer on Earth	3
• Provides some correct steps in calculating the time between the pulses, relative to an observer on Earth	2
• Provides some relevant information	1

Sample answer:

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

$$= \frac{3.1\times 10^{-9}}{\sqrt{1-0.9^2}}$$

$$= 7.1\times 10^{-9}\,\text{s}$$

Question 23 (a)

Criteria	Marks
• Calculates the magnitude of gravitational force	2
• Provides some relevant information	1

Sample answer:

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

$$= \frac{6.67\times 10^{-11}\times 1.99\times 10^{30}\times 6.1\times 10^{3}}{\left(1.52\times 10^{11}\right)^2}$$

$$= 35\,\text{N}$$

Question 23 (b)

Criteria	Marks
• Calculates the minimum photon energy the telescope can detect	3
• Provides some correct steps in calculating the minimum photon energy	2
• Provides some relevant information	1

Sample answer:

$$E = hf$$

$$= \frac{hc}{\lambda}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{2.8 \times 10^{-5}}$$

$$= 7.1 \times 10^{-21}\ \text{J}$$

Question 23 (c)

Criteria	Marks
• Calculates the temperature of the exoplanet	2
• Provides some relevant information	1

Sample answer:

$$\lambda = \frac{b}{T}$$

$$T = \frac{b}{\lambda}$$

$$= \frac{2.898 \times 10^{-3}}{1.14 \times 10^{-5}}$$

$$= 254\ \text{K}$$

Question 24

Criteria	Marks
• Calculates the required magnetic field	3
• Provides some correct steps in calculating the required magnetic field	2
• Provides some relevant information	1

Sample answer:

Using $F = qvB = \dfrac{mv^2}{r}$

$$B = \frac{mv}{rq}$$

$$= \frac{\left(9.109 \times 10^{-31} \times 3.0 \times 10^{6}\right)}{10 \times 1.602 \times 10^{-19}}$$

$= 1.7 \times 10^{-6}$ T out of the page

Question 25 (a)

Criteria	Marks
• Describes the function of part *X*	2
• Provides some relevant information	1

Sample answer:

Its function is to reverse the current in the loop, so that the loop continues in the same direction.

Question 25 (b)

Criteria	Marks
• Explains why the torque decreases	2
• Provides some relevant information	1

Sample answer:

As the speed increases, the back emf increases reducing the motor current and hence the torque.

Question 26

Criteria	Marks
• Calculates the energy released	3
• Provides some correct steps in calculating the energy released	2
• Provides some relevant information	1

Sample answer:

$$\begin{aligned}\Delta m &= m_p - m_r \\ &= (9.013u + 4.003u) - (12.064u + 1.008u) \\ &= -0.056u\end{aligned}$$

Hence $0.056 \times 931.5 = 52.16$ MeV

Answers could include:

8.356×10^{-12} J

Question 27 (a)

Criteria	Marks
• Explains how the composition and temperature of a star can be determined from its spectrum	4
• Explains how the composition OR temperature of a star can be determined by its spectrum	3
• Identifies features of a star's spectrum	2
• Provides some relevant information	1

Sample answer:

Composition can be deduced by looking at the absorption and emission spectra, because the lines present are unique for each element.

Temperature of the surface of the star can be determined from the measurement of the wavelength at which the radiation is at its peak intensity. This is because as a black body, this wavelength is related to its temperature.

Answers could include:

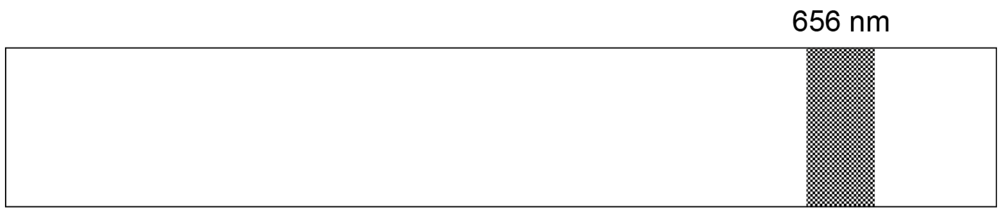
Presence of certain elements as an indication of temperature

Question 27 (b)

Criteria	Marks
• Explains the changes that would be observed in the spectral line AND correctly modifies the diagram	4
• Explains the effect of the star's rotation on the light detected	3
• Describes features in relation to the motion of the star OR correctly modifies the diagram	2
• Provides some relevant information	1

Sample answer:

As the star rotates on its axis, light on the side of the star approaching Earth is blue-shifted and the light on the receding side is red-shifted. Light from the centre is not Doppler shifted, as it is not approaching or receding. Because this effect increases towards the edges of the star, this will appear on the spectrum as shown.



Answers could include:

The motion of a star in a binary system

Question 28 (a)

Criteria	Marks
• Calculates the voltage output when the switch is open	2
• Shows a correct substitution	1

Sample answer:

$$V_s = V_p \times \frac{N_s}{N_p}$$

$$= 240 \times \frac{50}{300}$$

$$= 40 \text{ V}$$

Question 28 (b)

Criteria	Marks
• Relates the increase in current in the primary coil to the conservation of energy in the transformer	3
• Makes a correct statement about the conservation of energy in the coils	2
• Provides some relevant information	1

Sample answer:

With the switch closed, the lamps *X* and *Y* are in parallel, the total resistance is less than the resistance of lamp *X* alone. Therefore, the current through the secondary coil is greater when the switch is closed.

Since power out = power in, the current in the primary coil is greater when the switch is closed.

Question 29

Criteria	Marks
• Relates the interaction between the filter and differing planes of oscillation of the electromagnetic waves to the reduction of light intensity	4
• Relates the differing planes of polarisation of the light to the absorption of radiation by the polarising filter	3
• Outlines a relevant feature of light from an incandescent lamp OR • Outlines a feature of the interaction of electromagnetic radiation with a polarising filter	2
• Provides some relevant information	1

Sample answer:

Light from an incandescent lamp is unpolarised.

A polarising filter absorbs the component of the electric field of the electromagnetic wave that are not parallel to the polarisation direction of the filter.

The intensity of the light would be reduced as only the parallel components will pass through the filter.

Question 30 (a)

Criteria	Marks
• Relates the repulsive force, and the absence of force, on the ring to the induced current in the ring caused by the flux variation from the coil, and the interaction of the magnetic fields	4
• Relates some aspects of the force on the ring to electromagnetic induction	3
• Identifies electromagnetic induction in the ring	2
• Provides some relevant information	1

Sample answer:

From 0 to 0.03 seconds the magnetic field strength of the coil increases at a constant rate.

Hence the flux through ring *X* induces an electric current around the ring which produces a field that opposes the field of the coil, causing a repulsive force on ring *X*.

From 0.03 s to 0.05 s, the flux through the ring is constant and so no current is induced in the ring and hence there is no force of magnetic origin acting on ring *X*.

Question 30 (b) (i)

Criteria	Marks
• Explains the effect of the magnetic field on the ring	2
• Provides some relevant information	1

Sample answer:

The ring does not move because the gap in the ring means no current will flow. Therefore, there is no force on the ring.

Answers could include:

Reference to the production of eddy currents in the ring.

Question 30 (b) (ii)

Criteria	Marks
• Correctly calculates the voltage	2
• Makes any correct substitution into an appropriate formula	1

Sample answer:

$$\text{emf} = \frac{\Delta\varphi}{\Delta t}$$

$$= \frac{6 \times 10^{-3} \times 4 \times 10^{-4}}{3 \times 10^{-2}}$$

$$= 8 \times 10^{-5} \text{ volts}$$

Question 31

Criteria	Marks
• Explains the similarities and differences between the two sets of data	5
• Explains the similarities in the data sets AND describes the difference(s) OR • Explains the differences in the data sets AND describes the similaritie(s)	4
• Demonstrates some understanding of the similarities AND/OR differences between the data sets	3
• Compares features of the two sets of data	2
• Provides some relevant information	1

Sample answer:

Both lines have a similar shape which represents that the similarities are:

- The increasing engagement with the braking fin in both cases until it reaches a maximum at approximately 0.8 s. This is caused by more magnets engaging with the fin, causing a greater flux change in the fin, causing an increasing braking effect.
- After maximum braking, both cases have a reduction in braking due to slowing down of the roller coaster, meaning less opposing eddy currents are produced.

The differences are:

- The faster case has a greater maximum braking, because the high speed of the roller coaster created a greater maximum change in flux.
- The faster case also has greater braking for most of the time, until 3 s. This is because it is travelling faster and creating greater opposing eddy currents than in the slower case.

Answers could include:

Difference in the rate of change of acceleration between the cases.

Question 32

Criteria	Marks
• Calculates the position of the ball relative to the launcher's position	7
• Provides substantial working to calculate the range of the ball and the position of the launcher	5–6
• Provides some correct calculations in determining the range of the ball and the position of the launcher	3–4
• Describes the trajectory of the ball OR the motion of the launcher	2
• Provides some relevant information	1

Sample answer:

Calculating u_x

$$u_x = v_L = \frac{2\pi r}{t} = \frac{2\pi \times 2}{0.334} = 37.62\,\mathrm{m\,s^{-1}}$$

Noting t is the time for one revolution.

$$u_y = 5.72\,\mathrm{m\,s^{-1}}$$

Calculating time of flight from $v = u + at$

$$t = \frac{-2u_y}{-9.8} = 1.167\,\mathrm{s}$$

Range:

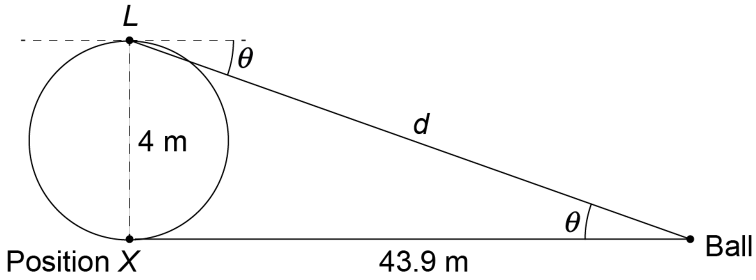
$$\begin{aligned} s &= u_x t \\ &= 37.62 \times 1.167 \\ &= 43.90\,\mathrm{m} \end{aligned}$$

Calculating position L after t:

$$\Delta\theta = 3 \times \frac{rev}{\mathrm{sec}} \times 1.167\,\mathrm{s} = 3.50$$

So L ends up half a revolution away from original position.

Calculating relative positions:



NOT TO SCALE

$$d = \sqrt{\left(43.9^2 + 4^2\right)} = 44.08\text{ m} \text{ from the launcher}$$

$$\theta = \tan^{-1}\left(\frac{4}{43.9}\right) = 5.2^\circ$$

Answers could include:

Variations in methods to calculate quantities and rounding leading to distances up to ≈ 44.20 m and θ down to ≈ 5.11°.

Question 33

Criteria	Marks
• Provides a reasoned detailed justification for the statement with explanation referencing at least TWO observations and at least TWO experiments	9
• Provides a justification for the statement with explanation referencing at least TWO observations and at least TWO experiments	7–8
• Provides a justification for the statement with an explanation of an observation/experiment of particle–field interactions and an observation/experiment of particle–particle interactions	5–6
• Provides details of TWO experiments or observations and how they relate to the statement	3–4
• Relates the statement to an experiment or observation OR • Describes relevant experiments or observations	2
• Provides some relevant information	1

Answers could include:

Reference to

- Thomson's experiment (particle–field) – q/m ratio of the electron
- Millikan's experiment (particle–field) – q of electron
- Photoelectric observations/experiments (particle–field) – quantum nature of light
- Particle accelerator observations/experiments (particle–particle and particle–field) – discovery of quarks and the standard model
- Chadwick's experiment (particle–particle) – neutron
- Geiger–Marsden (particle–particle) – nucleus
- Nuclear radiation experiment (particle–field) – charge of nuclear radiation
- Nuclear decay observations (particle–particle) – nature of the nucleus
- Davisson–Germer experiment (particle–particle) – wave nature of matter
- Observations of muons (particle–particle) – standard model, special relativity

And other related experiments/observations.

Question 34 (a)

Criteria	Marks
• Analyses qualitatively the energy changes as the satellite moves	2
• Provides some relevant information	1

Sample answer:

As the satellite moves, its kinetic energy decreases and is transformed into an increasing gravitational potential energy, consistent with the law of conservation of energy.

Question 34 (b)

Criteria	Marks
• Shows the kinetic energy is equal to 1.194×10^{10} J	4
• Provides calculations which show understanding of the system	3
• Provides a relevant calculation OR • Relates conservation of energy to the system	2
• Provides some relevant information	1

Sample answer:

Due to conservation of energy

$$E_Q = U_Q + K_Q = E_P + K_{engine}$$

$$\therefore K_Q = E_P + K_{engine} - U_Q$$

$$\text{So } U_Q = -\frac{GMm}{r} = -\frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 400}{6.85 \times 10^6}$$

$$= -2.337 \times 10^{10}$$

$$\therefore K_Q = -1.195 \times 10^{10} + 5.232 \times 10^8 - \left(-2.337 \times 10^{10}\right)$$

$$= 1.194 \times 10^{10}\,\text{J}$$

Question 34 (c)

Criteria	Marks
• Explains the motion of the satellite after it passes through *Q*	3
• Outlines the motion of the satellite with reference to relevant physics principles	2
• Provides some relevant information	1

Sample answer:

As it passes *Q*, the satellite has a velocity that exceeds the orbital velocity required for circular motion

$$K_Q = \frac{1}{2} m {v_Q}^2 \qquad \therefore \quad v_Q = \sqrt{\frac{2K_Q}{m}} = \sqrt{\frac{2 \times 1.194 \times 10^{10}}{400}} = 7.727 \times 10^3 \text{ m s}^{-1}$$

v_{req} to maintain circular orbit

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{6.85 \times 10^6}} = 7.644 \times 10^3 \text{ m s}^{-1}$$

ie $v_Q > v$

This means the satellite will continue on its trajectory increasing its distance from Earth.

Answers could include:

- a response based on the interpretation that *P*, Earth and *Q* are on the same line
- a response without calculations
- aspects of the conservation of energy.

2023 HSC Physics Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 5 Motion in Gravitational Fields	PH12-12
2	1	Mod 6 Electromagnetic Induction	PH12-13
3	1	Mod 7 Light Wave Model	PH12-14
4	1	Mod 8 Properties of the Nucleus	PH12-15
5	1	Mod 5 Motion in Gravitational Fields	PH12-12
6	1	Mod 7 Electromagnetic Spectrum	PH12-14
7	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15
8	1	Mod 5 Projectile Motion	PH12-12
9	1	Mod 7 Light Quantum Model	PH12-14
10	1	Mod 6 Applications of the Motor Effect	PH12-13
11	1	Mod 8 Properties of the Nucleus	PH12-15
12	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-13
13	1	Mod 8 Properties of the Nucleus	PH12-15
14	1	Mod 5 Motion in Gravitational Fields	PH12-6, 12-12
15	1	Mod 7 Light Quantum Model	PH12-14
16	1	Mod 6 The Motor Effect	PH12-13
17	1	Mod 5 Circular Motion	PH12-12
18	1	Mod 5 Projectile Motion	PH12-5, 12-12, 12-13
19	1	Mod 7 Light and Special Relativity	PH12-1, 12-13, 12-14
20	1	Mod 8 Origins of the Elements	PH12-6, 12-15

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 8 Origins of the Elements	PH12-15
21 (b)	3	Mod 8 Origins of the Elements	PH12-6, 12-15
22	3	Mod 7 Light and Special Relativity	PH12-12
23 (a)	2	Mod 5 Motion in Gravitational Fields	PH12-6, 12-12
23 (b)	3	Mod 7 Light Quantum Model	PH12-6, 12-14
23 (c)	2	Mod 7 Light and Special Relativity	PH12-14
24	3	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-6, 12-13
25 (a)	2	Mod 6 Applications of the Motor Effect	PH12-7, 12-13
25 (b)	2	Mod 6 Applications of the Motor Effect	PH12-13
26	3	Mod 8 Properties of the Nucleus	PH12-5, 12-15

Question	Marks	Content	Syllabus outcomes
27 (a)	4	Mod 7 Electromagnetic Spectrum	PH12-7, 12-14
27 (b)	4	Mod 7 Electromagnetic Spectrum	PH12-6, 12-14
28 (a)	2	Mod 6 Electromagnetic Induction	PH12-13
28 (b)	3	Mod 6 Electromagnetic Induction	PH12-13
29	4	Mod 7 Light Wave Model	PH12-7, 12-14
30 (a)	4	Mod 6 Electromagnetic Induction	PH12-13
30 (b) (i)	2	Mod 6 Electromagnetic Induction	PH12-13
30 (b) (ii)	2	Mod 6 Electromagnetic Induction	PH12-13
31	5	Mod 6 Application of The Motor Effect Mod 8 Structure of the Atom	PH12-5, 12-13
32	7	Mod 5 Circular Motion Mod 5 Projectile Motion	PH12-6, 12-12
33	9	Mod 8 Properties of Nucleus	PH12-7, 12-15
34 (a)	2	Mod 5 Motion in Gravitational Fields	PH12-5, 12-12
34 (b)	4	Mod 5 Motion in Gravitational Fields	PH12-12
34 (c)	3	Mod 5 Motion in Gravitational Fields	PH12-12