BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2015 HSC Physics
Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

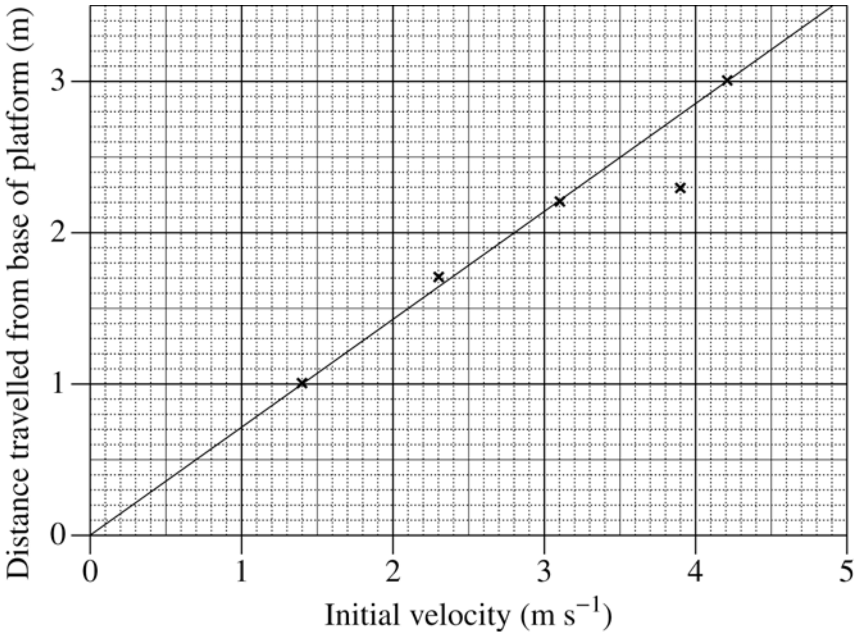
Question	Answer
1	C
2	B
3	B
4	D
5	A
6	B
7	C
8	C
9	B
10	A
11	D
12	D
13	C
14	C
15	A
16	C
17	A
18	A
19	D
20	B

Section I, Part B

Question 21 (a)

Criteria	Marks
• Plots all points correctly • Draws appropriate line of best fit	2
• Plots the majority of the points correctly	1

Sample answer:



Question 21 (b)

Criteria	Marks
• Applies correct processes to calculate the height of the platform	2
• Applies correct process to determine slope of graph/time of flight OR • Applies correct process to calculate the height of the platform using incorrectly obtained time	1

Sample answer:

Since

$$\triangle x = u_x t$$

$$\text{Slope of graph } = t$$

$$= \frac{2.5 - 0}{3.5 - 0} \quad \text{(values of slope will vary depending on line of best fit)}$$

$$= 0.714$$

$$\triangle y = ut + \frac{1}{2}at^2$$

$$= 0 + 0.5 \times 9.8 \times (0.714)^2$$

$$= 2.5$$

$\therefore$ Height of platform = 2.5 m

Question 22 (a)

Criteria	Marks
• Applies correct method to calculate the magnetic forces on the two sides • Includes the direction of the force on *AB*	3
• Applies correct method to calculate both magnetic forces OR • Applies correct method to calculate force on *AB* and provides its direction	2
• Substitutes into a relevant formula OR • Determines the direction/magnitude of a force correctly	1

Sample answer:

$$F_{AB} = BI\ell \sin\theta = 0.01 \times 1.0 \times 0.05 \times \sin 90°$$

$$= 5 \times 10^{-4}\,\text{N into the page}$$

$$F_{BC} = 0.01 \times 1.0 \times 0.05 \times \sin 0° = 0$$

There is a force of 5×10^{-4} N directed into the page acting on side *AB* due to the magnetic field whereas there is no force acting on side *BC* due to the magnetic field.

Question 22 (b)

Criteria	Marks
• Explains how the direction of the torque is maintained	2
• Provides some information about the direction of the current in the loop	1

Sample answer:

The split ring commutator reverses the direction of the current through the loop (initially the direction of conventional current is *ABCD*; after 90°, *DCBA*), ensuring that the torque remains in the same direction. This current reversal occurs twice during a 360° rotation of the loop.

Question 23 (a)

Criteria	Marks
• Outlines a procedure with steps that model the formation of holes, electron current and hole current	3
• Provides some steps that demonstrate the behaviour of a semiconductor	2
• Provides a step that demonstrates the behaviour of a semiconductor OR • Shows a basic understanding of modelling a semiconductor	1

Sample answer:

1. Seat 10 people on 10 chairs in a row to represent electrons in the valence band at zero kelvin.

2. Have two more people hold ⊕ / ⊖ signs to represent applied voltage.
3. Play music: to represent energy. Some students stand up, representing electrons moving into the conduction band.
4. Standing people move toward ⊕ representing electron flow.
5. Seated people shuffle toward ⊕ so the empty chairs move towards the ⊖, representing hole flow.

Question 23 (b)

Criteria	Marks
• Explains a limitation	2
• Identifies a limitation	1

Sample answer:

There is nothing in this model which represents the size of the band gap, therefore the behaviour of different semiconducting materials cannot be modelled.

Question 24 (a)

Criteria	Marks
• Correctly identifies inaccuracies in the path drawn and gives reasons	3
• Identifies inaccuracies in the diagram OR • Correctly identifies one inaccuracy and gives a reason	2
• Provides some relevant information relating to an inaccuracy in the diagram	1

Sample answer:

The electron is deflected in the wrong direction because it should be attracted towards the positive plate (or repelled by the negative plate).

The electron does not suddenly get deflected at the midpoint as shown because the plate's field deflects the electron from the point it enters the region between the plates on the left.

Answers could include:

The electron does not follow a straight path anywhere between the plates because its acceleration is uniform towards the positive plate.

[Accurate drawing with annotations is also acceptable.]

Question 24 (b)

Criteria	Marks
• Applies a correct method to calculate force	2
• Substitutes into a relevant formula	1

Sample answer:

$$E = \frac{F}{q} \quad \text{and} \quad E = \frac{v}{d}$$

$$\therefore \frac{F}{q} = \frac{v}{d} \qquad F = \frac{Vq}{d}$$

$$= \frac{5000 \times 1.6 \times 10^{-19}}{0.02}$$

$$= 4 \times 10^{-14} N$$

Question 24 (c)

Criteria	Marks
• Applies a correct method to calculate velocity	2
• Substitutes into a relevant formula	1

Sample answer:

$$a = \frac{F}{m}$$

$$= \frac{4 \times 10^{-14}}{9.1 \times 10^{-31}}$$

$$= 4.4 \times 10^{16} ms^{-2}$$

$$v^2 = u^2 + 2ay$$

$$v = \sqrt{2 \times 4.4 \times 10^{16} \times 0.02}$$

$$= 4.19 \times 10^7 ms^{-1}$$

Answers could include:

Other methods, eg using electrical energy → kinetic energy also possible.

Question 25 (a)

Criteria	Marks
• Identifies TWO devices and outlines the two energy transformations involved	3
• Outlines the conversion of electrical energy by a device in the home to another form of energy	2
• Shows a basic understanding of energy transformation	1

Sample answer:

Motors (as found in fans, drills and blenders) convert electrical energy to kinetic energy.

Toasters, jugs, etc use heating elements to convert electrical energy to heat.

Question 25 (b)

Criteria	Marks
• Calculates input and output power • Refers to law of conservation of energy	3
• Compares input and output power	2
• Performs a relevant calculation OR • Provides some relevant information about the transformer	1

Sample answer:

From data given

Power in $= V_{in} \times I_{in}$

$= 240 \text{ V} \times 5\text{A}$

$= 1200 \text{ W}$

These values of 240 V and 5 A are consistent with household electricity supply.

Power out $= 2000 \text{ V} \times 1 \text{ A}$

$= 2000 \text{ W}$

This is not consistent with law of conservation of energy – more energy out than in.

Question 26 (a)

Criteria	Marks
• Identifies assumptions made	2
• Provides relevant information about an assumption made	1

Sample answer:

Model X assumes the Earth's gravitational field is uniform/unchanging/linear from the surface upwards.

Model Y assumes the gravitational field changes with altitude.

Question 26 (b)

Criteria	Marks
• Provides correct reason	1

Sample answer:

Variations in gravitational attraction from the Earth's surface to an altitude of 200 km are sufficiently small to ensure the results from the two models are not significantly different.

Question 26 (c)

Criteria	Marks
• Applies a correct method to calculate velocity • States the correct units in the answer	3
• Shows understanding of the relationship between F_c and F_g and attempts at manipulating relevant formulae to find v OR • Attempts to calculate velocity using Kepler's law	2
• Substitutes into a relevant formula	1

Sample answer:

$$F_c = F_g$$

$$\frac{mv^2}{r} = \frac{GMm}{d^2}$$

$$v^2 = \frac{GM\not{m}\,\not{r}}{d^{\not{2}}\,\not{m}}$$

$$= \frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{6.58 \times 10^{6}}$$

$$= 6.08 \times 10^{7}$$

$$\therefore \quad v = 7797 \text{ m s}^{-1}$$

Question 27

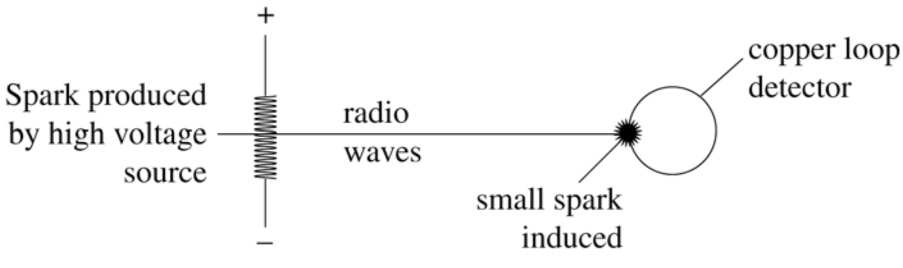
Criteria	Marks
• Describes how Hertz performed experiments to test Maxwell's predictions • Describe how Hertz validated the theory	6
• Describes Hertz's experiments and outlines how he validated the theory OR • Describes how Hertz validated the theory and outlines his experiments	5
• Provides an outline of Hertz's experiments and how he validated the theory OR • Describes Hertz's experiments or how he validated the theory	4
• Provides an outline of Hertz's experiment(s) or how he validated the theory	3
• Identifies a feature of Hertz's experiments or how a theory can be validated	2
• Identifies a feature of one of Hertz's experiments OR • Provides some relevant information about testing or validating a scientific theory	1

Sample answer:

Hertz performed a series of experiments that were designed to demonstrate:

1. The existence of 'invisible' electromagnetic waves (radio waves)
2. That the invisible waves behaved like visible light
3. That the speed of the waves was the speed of light.

His basic design involved using a high voltage source to produce a spark and a detector formed from a loop of copper wire with a small gap. Radio waves produced by the spark were detected when a tiny spark was induced across the gap in the detector.



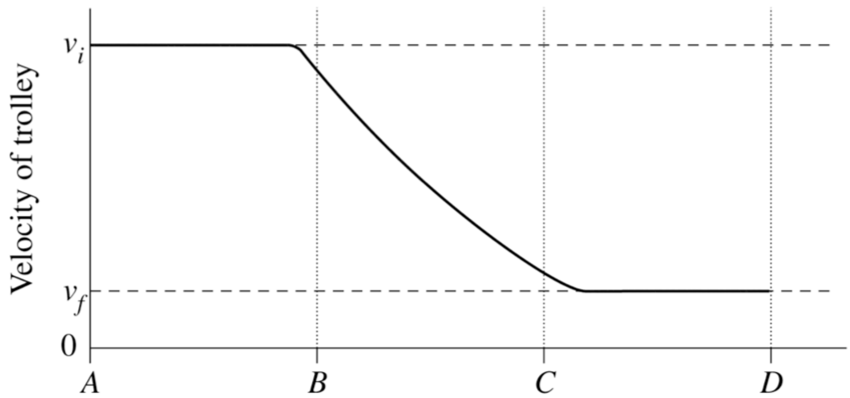
Further experiments using reflecting surfaces and other apparatus showed that radio waves can be reflected and refracted, behaviours consistent with visible light. A modification of the basic design allowed him to determine the velocity of the radio waves, using an interference pattern to determine their wavelength. Since the frequency was determined by the high voltage source, the wave equation $v = f\lambda$ could be used. The value obtained was the speed of light.

These experiments therefore provided substantial experimental evidence supporting the predictions made by Maxwell, thus validating the theory.

Question 28

Criteria	Marks
• Sketches a graph showing clearly where the velocity of the trolley is uniform and where it is decreasing • Provides a justification demonstrating understanding of the relationship between the graph and the effects of changing flux through the plate	5
• Sketches a substantially correct graph • Justifies some features of the graph in terms of the effects of changing flux through the plate	4
• Sketches a substantially correct graph OR • Sketches a graph that shows a decrease in the trolley's velocity and justifies a feature of the graph	3
• Sketches a graph with some correct features OR • Sketches a graph with one correct feature and provides some relevant information about the magnetic field OR • Relates features of the graph to the effects of a force acting on the trolley	2
• Provides one correct feature of the graph OR • Provides some relevant information about the magnetic field	1

Sample answer:



The velocity of the trolley is reduced as it passes through the region under the magnet (B) because its kinetic energy is transformed into heat energy in the copper plate.

This happens because of the flux change produced by the movement of the Cu plate through the field of the strong magnet. This induces currents in the Cu plate (Faraday's law) that produce a magnetic field that opposes the changing flux (Lenz's law) and hence produces a force that decelerates the trolley.

Question 29 (a)

Criteria	Marks
• Identifies advantages	2
• Identifies an advantage	1

Sample answer:

Strong magnetic fields are required to deflect the protons due to their high speeds and the effect of mass dilation.

To produce strong fields, high currents are required and superconductors allow very high current flow.

Question 29 (b)

Criteria	Marks
• Discusses the application of special relativity to protons in the LHC	3
• Outlines the application of special relativity to the protons in the LHC	2
• Provides some relevant information about special relativity	1

Sample answer:

Because the protons are travelling at almost the speed of light, special relativity dictates that mass dilation will be significant.

Mass dilation means an increasing amount of energy is needed to accelerate the proton.

[Answer could also include effects of length contraction/time dilation or identification of the non-inertial frame of reference.]

Question 30

Criteria	Marks
• Explains how the Law of Universal Gravitation and motion laws were applied to the three parts of the mission: launch, travelling to Saturn, orbiting Saturn	6
• Explains how at least three of the laws were applied to parts of the mission	5
• Outlines how at least two of the laws were applied to parts of the mission	4
• Outlines how at least two of the laws were applied to a part of the mission OR • Outlines how one of the laws was applied to parts of the mission	3
• Outlines how one of the laws was applied to a part of the mission	2
• Provides some relevant information about the mission or one of the laws	1

Sample answer:

Launching the probe from the surface of the Earth requires the application of Newton's 3rd law, in the operation of the rocket. This occurs when exhaust gases are expelled downwards and hence apply an upwards force on the rocket. During launch, the acceleration of the vehicle is governed by the mass of the vehicle and the force/thrust of the engines as described by Newton's second law.

Newton's first law of motion is relevant during the journey to Saturn. The probe is travelling through space and so does not experience friction or air resistance and so continues in its motion affected only by the gravity of the Sun and hence the Law of Universal Gravitation.

The Slingshot effect utilises the law of gravitation as well as conservation momentum (3^{rd} Law) to increase the velocity of the space probe.

A stable orbit can be predicted using the law of gravitation. The orbital velocity will determine the radius of the orbit.

Section II

Question 31 (a) (i)

Criteria	Marks
• Calculates densities and compares them quantitatively	2
• Uses appropriate method to calculate a density OR • Correctly compares densities based on results	1

Sample answer:

$$\text{Density granite} = \frac{92.4}{185-150} = 2.64\,\text{g cm}^{-3}$$

$$\text{Density basalt} = \frac{119.0}{190-150} = 2.975\,\text{g cm}^{-3}$$

Basalt is more dense than granite.

Question 31 (a) (ii)

Criteria	Marks
• Describes physical properties of the rocks that can be studied	3
• Identifies physical properties of the rocks that can be studied OR • Describes one physical property of the rocks that can be studied	2
• Identifies a property of the rocks that can be studied	1

Sample answer:

Two other properties of rocks that geophysicists study are elasticity and magnetism. Elasticity is a measure of how much the rock deforms when a force is applied to it. Magnetism is dependent on the nature and amount of magnetic material present that alters the interaction between the rock and external magnetic fields.

Answers could include:

Properties including thermal, electrical, magnetic.

Question 31 (b) (i)

Criteria	Marks
• Describes a long-term change in Earth's magnetic field	2
• Identifies magnetic reversals or polar wandering OR • Identifies changes in field strength	1

Sample answer:

The Earth's magnetic field undergoes periodic reversals – where North and South Poles are reversed. These occur at varying time intervals but have happened many times throughout Earth's history.

Answers could include:

Polar wandering.

Question 31 (b) (ii)

Criteria	Marks
• Outlines causes for changes in Earth's magnetic field	3
• Identifies causes for changes to Earth's magnetic field OR • Outlines a cause for changes to Earth's magnetic field	2
• Identifies a cause for changes to Earth's magnetic field	1

Sample answer:

Convection currents in the mantle and outer core produce changes in ionic concentrations/flow rates, which change the field.

The rate of rotation of the liquid parts of Earth's interior is not the same as the crust's period and the rotation rate varies with depth and latitude and this changes the field of Earth.

Answers could include:

Other changes such as axial tilt, formation of new crust, subduction of crust also change Earth's field.

Question 31 (c)

Criteria	Marks
• Relates what can be deduced to the satellites' motions • Relates differences in 'g' values to internal structure/composition of Earth	4
• Relates the measurement of differences in 'g' to the changing distances between S1 and S2 OR • Relates differences in 'g' to different structures/compositions in Earth's interior	3
• Identifies what can be deduced • Provides some link to the satellites or the structure of Earth	2
• Provides some relevant information	1

Sample answer:

Variations of Earth's gravitation field can be deduced using these satellites and hence inferences can be made about Earth's shape and the distribution of materials of different density inside Earth.

If S1 passes over a region of Earth that is of greater density, the increased force of gravity on S1 causes it to speed up and this is detected by the increasing separation between S2 and S1.

Analysis of large amounts of accumulated data as the relative positions of the orbits of S1/S2 and Earth change due to Earth's rotation on its axis permits a detailed 3D model of Earth's gravitational field to be deduced and this provides an insight into Earth's internal structure/composition.

Question 31 (d) (i)

Criteria	Marks
• States the relationship	2
• Identifies an aspect of the relationship	1

Sample answer:

The speed of the P waves is directly proportional to the density (of the outer core).

OR

Density and P wave speed increase at the same rate.

Question 31 (d) (ii)

Criteria	Marks
• Relates the three aspects of the P waves' behaviour to relevant changes in Earth's interior	3
• Relates changes in the P waves' paths to change in Earth's interior	2
• Links a change in the P waves' path to a change in Earth's interior OR • Provides some relevant information about Earth's interior or the path of the P wave	1

Sample answer:

The paths of the P waves in the mantle curve due to P wave velocity increasing with depth, therefore producing refraction. The P waves are partly reflected at the mantle/outer core boundary due to the abrupt density changes at the boundary. The P waves refract and follow a curved path in the outer core due to increasing density with depth.

Question 31 (e)

Criteria	Marks
• Makes an informed judgement explicitly/implicitly about the impact of the applications of remote sensing on society • Supports answer using THREE specific applications	6
• Makes an informed judgement explicitly/implicitly about the impact of the applications of remote sensing on society • Supports answer using at least TWO specific applications	5
• Outlines some effects of the applications of remote sensing on society • Supports answer using at least ONE specific application	4
• Identifies example(s) and/or feature(s) of remote sensing AND/OR • Outlines an effect of remote sensing on society	2–3
• Identifies an example or a feature of remote sensing	1

Sample answer:

Remote sensing has had a significant impact on society as evidenced by the following examples.

Satellites have improved the accuracy of weather forecasts by producing images that track major weather events such as cyclones. This provides advance warning which allows property to be protected and many lives to be saved.

Monitoring vegetation using I.R. sensors has allowed crop yields to be predicted so that production shortages can be planned for thus allowing for food to be sent to areas where shortages are likely.

Mineral exploration such as detection of iron ore deposits using magnetic sensors can be done more quickly giving society faster access to such resources.

Question 32 (a) (i)

Criteria	Marks
• Makes link between strength of reflection at tissue boundaries and differences in acoustic impedance, and therefore a reflection indicates different tissue types	2
• Identifies a feature of ultrasound or different types of body tissue	1

Sample answer:

When ultrasound strikes a boundary between two different types of tissue, reflection will only occur if there is a difference in acoustic impedance between the tissues.

Tissues such as bone, muscle, fat and blood have significantly different acoustic impedances and therefore a strong reflection will occur at such boundaries, allowing the sonographer to easily distinguish between the two types.

Question 32 (a) (ii)

Criteria	Marks
• Applies correct methods to calculate the acoustic impedance of bone and the ratio of reflected to initial intensity of ultrasound	3
• Applies correct method to calculate the acoustic impedance of bone • Substitutes into a relevant formula to calculate the ratio	2
• Substitutes into a relevant formula	1

Sample answer:

Calculate acoustic impedance of bone

$Z = \rho v = 1910 \times 4080 = 7.79 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

Calculate ratio

$$\frac{I_r}{I_o} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2} = \frac{\left[7.79 \times 10^6 - 1.71 \times 10^6\right]^2}{\left[7.79 \times 10^6 + 1.71 \times 10^6\right]^2}$$

$$= 0.41$$

Question 32 (b) (i)

Criteria	Marks
• Outlines TWO differences	2
• Outlines ONE difference	1

Sample answer:

An X-ray uses X-radiation produced by an X-ray tube whereas a PET scan uses gamma rays produced by positron-electron interaction. The source of the X-radiation is outside the body whereas the source of the gamma rays is inside the body.

Question 32 (b) (ii)

Criteria	Marks
• Provides a justification that includes relevant limitation(s) of conventional X-ray and advantage(s) of PET scans	3
• Outlines a limitation of conventional X-ray OR • Outlines an advantage of PET scans OR • Identifies a limitation of conventional X-ray and an advantage of PET scans OR • Identifies limitations of conventional X-ray or advantages of PET scans	2
• Provides some relevant information about PET scans or conventional X-rays	1

Sample answer:

The failure of the X-ray image to show the presence of any tumours is not sufficient to clear the patient of lung cancer. Conventional X-rays do not image soft tissue well and during treatment, the size of the tumours may have decreased to below the limit of resolution.

The PET scan, however, is very effective at detecting regions of high metabolic activity, which is characteristic of tumours, regardless of size. This is because the radioisotope/radiopharmaceutical used is metabolised at different rates by the body tissues and organs, resulting in an easily identifiable ‘hot spot’ if the activity is unusually high. A ‘whole body’ scan will also detect if the cancer has spread to other parts of the body.

Question 32 (c)

Criteria	Marks
• Describes how the structure of an endoscope enables it to detect the presence of a tumour and collect tissue sample	4
• Outlines how an endoscope is used to detect the presence of a tumour and collect tissue sample OR • Describes how an endoscope is used to detect the presence of a tumour OR • Describes how an endoscope is used to collect tissue sample	3
• Identifies relevant parts of an endoscope OR • Outlines a function of a relevant part	2
• Identifies a feature of an endoscope	1

Sample answer:

An endoscope is an instrument that carries light and small instruments inside the human body while conveying images back to the operator.

It consists of:

1. a bundle of optic fibres to carry light to the tissue
2. a coherent bundle of optic fibres to carry an image of the tissue (eg tumour) to the operator
3. lenses at either end of the bundle to focus the image or connect to a recording device
4. control lines to manipulate the position in the patient
5. miniature remotely controlled surgical tools to obtain the tissue sample (eg tumour biopsy).

Question 32 (d) (i)

Criteria	Marks
• Outlines how MRI scans distinguishes between grey and white matter in the brain	2
• Provides some relevant information about grey or white matter or relaxation times	1

Sample answer:

Differences in the T1 and T2 relaxation times are dependent on the water content in different tissues. Because the water content of white and grey matter in the brain is different, relaxation time data from these tissues can be analysed to produce images that clearly show the locations of the different tissue types.

Question 32 (d) (ii)

Criteria	Marks
• Describes how the process of resonance is used in the production of an MRI scan	3
• Outlines the process of resonance OR • Shows an understanding of the relationship between the Larmor frequency and the absorption of the energy of a radio pulse of the same frequency OR • Shows an understanding of the relationship between the absorption of the radio pulse and the detection of a signal	2
• Provides some relevant information about resonance or MRI	1

Sample answer:

When two objects have the same natural frequency, energy can be transferred efficiently between them – a process called resonance. To produce an MRI scan a very strong magnetic field is applied that causes protons in the body to align with the field and process at a particular frequency – the Larmor frequency. A radio pulse at the same frequency is then applied causing the protons to resonate, effectively absorbing the energy of the pulse and locking them in phase with each other. Changes in the net magnetic field produced by the protons when the RF pulses stop are measured and the data are analysed to produce a MR image.

Question 32 (e)

Criteria	Marks
• Relates THREE different imaging technologies to advances in understanding of waves • Makes an informal judgement explicitly/implicitly about the impact of these advances on the development of imaging technologies	6
• Identifies THREE imaging technologies • Relates at least TWO of them to advances in understanding of wave properties • Outlines some effects of advances in understanding of waves on the development of imaging technologies	5
• Relates at least TWO imaging technologies to relevant wave property(ies) and/or behaviour(s) • Outlines an effect of advances in understanding of waves on the development of imaging technologies	4
• Relates an imaging technology to a relevant wave property or behaviour AND/OR • Identifies advances in understanding of waves or development of imaging technologies	2–3
• Provides some relevant information about an imaging technology or waves	1

Sample answer:

Understanding waves has had a significant impact on the development of imaging technologies.

Ultrasound is a technology based on the understanding of reflection and refraction of sound waves when they strike a boundary between two different tissues. Knowledge of the relative intensity of the incident and reflected sound wave is essential if an image is to be constructed of the two tissues.

X-ray images are produced using differences in absorption of X-radiation by different body tissues. Understanding that more dense tissues such as bone absorb more X-radiation is therefore essential if a contrast is to be produced between tissues on the X-ray.

The endoscope is used to transmit light inside the body so real time images of internal structures can be seen. The structure of the optical fibres used to transmit the light is based on understanding that light is totally internally reflected when it strikes a boundary between a more optically dense and less optically dense medium at an angle greater than the critical angle.

Question 33 (a) (i)

Criteria	Marks
• Applies correct method to calculate apparent magnitude	2
• Substitutes into a relevant formula	1

Sample answer:

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

$$-5.51 = m - 5\log\left(\frac{95.9}{10}\right)$$

$$m = 5\log\left(\frac{95.9}{10}\right) - 5.51$$

$$= 4.91 - 5.51$$

$$= -0.60$$

Question 33 (a) (ii)

Criteria	Marks
• Correctly outlines TWO methods	3
• Outlines one method OR • Identifies two methods	2
• Identifies one method	1

Sample answer:

Distances to stars can be determined using:

- trigonometric parallax: the apparent shift in a nearby star against the background stars is observed over 6 months and then $d = \frac{1}{p}$ is used
- spectroscopic parallax: the apparent magnitude of a star is measured, the absolute magnitude of the star is estimated from its spectral class and luminosity class, and then the distance modulus used
- distance to Cepheids through period/luminosity relationship and then distance modulus.

Question 33 (b) (i)

Criteria	Marks
• Provides an explanation	2
• Provides some relevant information about one of the light curves shown OR • Identifies a reason	1

Sample answer:

These types of light curves are produced by eclipsing binary systems, where the stars regularly eclipse each other with respect to Earth. This only occurs when the plane of orbit is in line with our view of the stars.

Answers could include:

At very large distances, small changes in magnitude may not be detected.

Question 33 (b) (ii)

Criteria	Marks
• Correctly relates features of both curves to properties of both stars in the system	3
• Correctly relates features of one curve to properties of stars in the system OR • Correctly links a property of stars to each curve	2
• Links a feature of one of the curves to a property of the stars	1

Sample answer:

The curve on the left shows a binary system consisting of a hotter star and a cooler star. When the hotter star is eclipsed, the greater decrease in brightness occurs than when the cooler star is eclipsed by the hotter star. The flattened bottom shows that they have different radii, as total eclipse occurs for a period of time.

The right hand curve shows a system containing two stars with same size and temperature – total eclipse is only momentary and no difference during eclipse (equal drop in brightness).

Answers could include:

Reference to: luminosity of stars; spectral class.

Question 33 (c)

Criteria	Marks
• Explains production of emission and absorption spectra by specific types of celestial objects	4
• Explains production of emission or absorption spectra by specific type of celestial objects OR • Outlines production of emission and absorption spectra	3
• Outlines how emission or absorption spectra are produced OR • Identifies specific types of celestial objects that produce each type of spectra	2
• Identifies a feature of emission or absorption spectra	1

Sample answer:

Emission spectra are produced when electrons within atoms are excited to higher energy levels. When these electrons return to ground state they release photons of particular wavelengths. In space, emission nebulae are heated by nearby hot stars, and produce emission nebulae. Quasars also produce emission spectra superimposed on continuous spectra.

Absorption spectra are produced when atoms absorb particular wavelengths as light passes through them. Electrons absorb particular wavelengths to 'jump' to higher energy levels. The wavelengths correspond to differences in energy levels.

Cores of stars tend to produce continuous spectra and as this light passes through the outer layers of the stars particular wavelengths are absorbed – depending on the temperature and atoms or molecules present. Most stars therefore produce absorption spectra.

Question 33 (d) (i)

Criteria	Marks
• Correctly identifies curve and gives justification	2
• Correctly identifies curve OR • Provides some relevant information about *W*	1

Sample answer:

Curve A. *W* is hotter so will emit more energy overall, and peak frequency will be higher.

Question 33 (d) (ii)

Criteria	Marks
• Uses position on H-R diagram to account for differences between the stars	3
• Accounts for a difference OR • Provides some features of stars *W* and *Z*	2
• Provides some relevant information about star *W* or star *Z* OR • Identifies an area of difference (eg fuel source, size, temperature)	1

Sample answer:

Star *W* is main sequence and so is fusing hydrogen to helium, most likely via CNO cycle as it is a large dense star.

Star *Z* is past main sequence so is fusing larger elements. It is cooler than *W* (from its position on the H-R diagram) but has similar luminosity – this would suggest it is much larger than *W*.

Answers could include:

Differences in fuel source, size and temperature of the stars

Question 33 (e)

Criteria	Marks
• Relates features and applications of space-based telescopes to the understanding of celestial objects • Makes an informed judgement explicitly/implicitly of the impact of the development of space-based telescopes on the understanding of celestial objects	6
• Relates features and/or applications of space-based telescopes to the understanding of celestial objects • Outlines some effects of the development of space-based telescopes on the understanding of celestial objects	5
• Links features and/or applications of space-based telescopes to the understanding of celestial objects • Outlines an effect of the development of space-based telescopes on the understanding of celestial objects	4
• Identifies relevant features of space-based telescopes AND/OR • Outlines an example of a relevant application of space-based telescopes	2–3
• Provides some relevant information about space-based telescopes	1

Sample answer:

The development of space-based telescopes allows astronomers to avoid a number of problems associated with ground-based telescopes.

Space-based telescopes are above the atmosphere and so they are able to detect wavebands that are normally absorbed. This includes X-rays and infra-red. Being able to detect these wavebands gives astronomers more detail about stars and galaxy structure.

Space-based telescopes do not experience atmospheric distortion and so can achieve better resolution images with a smaller mirror. This allows the telescopes to better identify astrometric binaries and measure motions and distances of stars (using parallax).

Linking a space telescope and a ground telescope can create a very long baseline interferometer that further improves resolution, particularly for radio waves, used to study galaxy structure.

Space-based telescopes are therefore a very valuable tool for astronomers studying celestial objects. However, costs and logistical problems mean that ground-based telescopes will always have an important role.

Question 34 (a) (i)

Criteria	Marks
• Outlines how a Wilson Cloud Chamber or similar device can be used to distinguish between alpha and beta decay	2
• Identifies a feature of a Wilson Cloud Chamber or a similar device or alpha decay or beta decay	1

Sample answer:

In a Wilson Cloud Chamber the paths of alpha and beta particles can be seen. Alpha particles produce shorter, thicker trails.

Question 34 (a) (ii)

Criteria	Marks
• Applies correct methods to calculate mass defect and the energy released, in either MeV or J	3
• Applies a correct method to calculate mass defect or the energy released	2
• Substitutes into a relevant formula	1

Sample answer:

Po-218 -> Pb-214 + He-4
Mass of products = 218.00241 u
Mass of reactant = 218.00897 u
Mass defect = mass of reactant – mass of products
= 0.00656 u

$E = mc^2$
$= 0.00656 \times 1.661 \times 10^{-27} \times (3 \times 10^8)^2$
$= 9.8 \times 10^{-13}$ J

OR

$E = 931.5$ MeV $\times\ 0.00656$
$= 6.1$ MeV

Question 34 (b) (i)

Criteria	Marks
• Applies correct method to calculate the speed (including unit conversion)	2
• Substitutes into a relevant formula	1

Sample answer:

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

$$v = \frac{h}{(\lambda \times m)}$$

$$= \frac{6.626 \times 10^{-34}}{\left(0.2 \times 10^{-9} \times 1.675 \times 10^{-27}\right)}$$

$$= 1978 \text{ m s}^{-1}$$

Question 34 (b) (ii)

Criteria	Marks
• Explains why the neutron beam is useful in determining the structure of materials	3
• Identifies relevant features of the neutron beam OR • Outlines a relevant feature of the neutron beam	2
• Identifies a relevant feature of the neutron beam	1

Sample answer:

The beam of neutrons can be used in scattering experiments. The extremely small wavelength makes the neutron beam suitable for studying matter at the atomic level, as it allows much smaller objects to be distinguished, than say visible light. The fact that the neutrons have no electric charge prevents them from being affected by the presence of protons and electrons, allowing them greater penetration into the material.

Question 34 (c)

Criteria	Marks
• Explains the importance of the spectroscope in the development of the model	4
• Links feature(s) of the spectroscope to Bohr's model	3
• Identifies relevant features of the spectroscope and/or Bohr's model OR • Outlines a relevant feature of the spectroscope	2
• Identifies a feature of the spectroscope or Bohr's model	1

Sample answer:

The Rutherford model of the atom consisted of a positive nucleus and surrounding electrons, however it was not known how the electrons were arranged, or how they were prevented from radiating their energy. The spectroscope allowed scientists to identify the characteristic spectrographic lines of different elements, including hydrogen. These lines caused Bohr to hypothesise the existence of stable and fixed orbits for the electrons, since it suggested that there were fixed gaps between the available energy levels. Without the spectroscope Bohr would not have made this hypothesis and would not have developed his model of the atom.

Question 34 (d) (i)

Criteria	Marks
• States the conclusion with reference to the results	2
• Provides some relevant information about the conclusion or the results	1

Sample answer:

Davisson and Germer found that the electrons formed an interference pattern after passage through the crystal. Since interference is a phenomenon only observed with waves they concluded that electrons were also waves.

Question 34 (d) (ii)

Criteria	Marks
• Recognises that the identification of the wave properties of electrons helps to solve a particular problem with the Rutherford-Bohr model	3
• Links the wave property of the electron to the model	2
• Provides some relevant information about the wave properties of electrons OR the Rutherford-Bohr model	1

Sample answer:

The Rutherford-Bohr model consisted of fixed electron orbits, but it was unable to explain why only these orbits were stable. The knowledge that electrons are waves enables an explanation, as indicated by de Broglie, where the electron can only exist in orbits where it experiences constructive interference.

Question 34 (e)

Criteria	Marks
• Provides THREE advances in knowledge about particles and forces • Makes an informed judgement explicitly/implicitly about their impact on the understanding of the atomic nucleus	6
• Provides THREE advances in knowledge about particles and/or forces • Outlines their impact on the understanding of the atomic nucleus OR makes an informed judgement explicitly/implicitly about the impact of TWO of the advances	5
• Provides at least TWO advances in knowledge about particles and/or forces • Outlines their impact on the understanding of atomic particles	4
• Outlines the impact of ONE advance in knowledge about particles or forces AND/OR • Identifies advances in knowledge about particles and/or forces	2–3
• Provides some relevant information about the nucleus/particles/forces	1

Sample answer:

Understanding of particles and forces is essential to allow a comprehensive knowledge of the structure and behaviour of the nucleus, as shown in these examples.

The discovery of the neutron allowed scientists to understand the masses of the nuclei and to better identify trends in both the periodic table and nuclear stability.

Knowledge of the strong nuclear force helps us to explain how protons are held in the nucleus, in spite of the repulsion due to the electrostatic force, and helps to explain why certain isotopes are unstable.

The discovery that protons and neutrons are made from different combinations of two types of quarks helped to unify understanding of subatomic particles, as part of the Standard Model.

Question 35 (a) (i)

Criteria	Marks
• Provides a truth table with all four possible combinations of inputs, and correct outputs	2
• Provides a truth table with some correct entries	1

Sample answer:

Input		*Output*
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

Question 35 (a) (ii)

Criteria	Marks
• Determines if the substitution is valid and provides appropriate justification	3
• Compares logic of unknown gate and logic of original circuit AND/OR • Provides some relevant reasoning	2
• Provides some relevant information	1

Sample answer:

Any voltage less than 2.5 V is considered low, or 0, in a logic circuit. The inputs to the gate are therefore A = 0 and B = 1, giving an output of C = 1. This is consistent with the output of the original circuit as shown in the truth table.

However, it would not be a valid substitute as the other possible inputs cannot be checked.

Question 35 (b) (i)

Criteria	Marks
• Applies a correct method to calculate both upper and lower limits of voltage	2
• Substitutes into a relevant formula OR • Calculates values for both the upper and lower bounds of the variable resistor, using an incorrect method	1

Sample answer:

$$V_{out} = \frac{(V_{in} \times R_1)}{(R_1 + R\ )}$$

When resistance of variable resistor (R_2) = 1000 ohms

V_{out} = 8.2 V

When R_2 = 20 000 ohms

V_{out} = 3.0 V

Question 35 (b) (ii)

Criteria	Marks
• Identifies a possible use of the circuit • Relates features of the circuit to this application	3
• Links features of the circuit to an application OR • Identifies a possible use of the circuit and links one of the features of the circuit to this application	2
• Identifies a possible use of the circuit OR • Outlines the role of one of the features of the circuit	1

Sample answer:

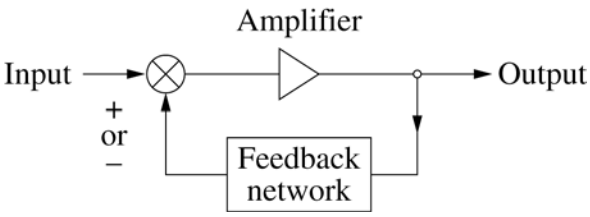
A possible use for this circuit would be as a fire alarm. Because fire would cause the thermistor to heat up, it would change the voltage across the diode. When the voltage reaches a particular value it would close the switch on the relay, which could be connected to a speaker system to trigger an alarm.

Question 35 (c)

Criteria	Marks
• Explains how amplifiers and feedback loops are used in control systems • Supports answer with a diagram	4
• Explains how amplifiers and/or feedback loops are used in control systems OR • Outlines how amplifiers and/or feedback loops are used in control systems with the support of a diagram	3
• Provides a diagram with a loop AND/OR • Outlines how amplifiers and/or feedback loops are used in control systems	2
• Shows a basic understanding of control systems/amplifiers/feedback loops OR • Provides a relevant simple diagram	1

Sample answer:

Control systems, such as in industrial, communications, medical and entertainment applications, use feedback loops (closed-loop systems) to amplifiers to reduce variations prevalent in open loop systems. A feedback loop is where part of the output is transmitted back to become part of the input, as shown.



Negative feedback is most common in control systems where the signal is out of phase and subtracted from the input to reduce gain. This improves performance (gain stability, linearity and frequency response) and reduces sensitivity to parameter variations (manufacture) or environment (temperature or voltage).

Positive feedback (addition to input) causes instability (hysteresis) and can be used for comparitors or oscillators (such as in timing circuits).

Question 35 (d) (i)

Criteria	Marks
• Explains ONE advantage	2
• Identifies ONE advantage OR • Shows a basic understanding of integrated circuits/circuits constructed from individual components	1

Sample answer:

Miniaturisation:
Large numbers of transistors and other components can be manufactured onto a single silicon chip, making it small, durable and requiring lower energy levels to operate.

Answers could include:

Cost of Production:
Many individual components can be printed onto a silicon chip to perform a specific function compared to the cost of producing many single components then having to assemble them onto a circuit board to serve a function.

Question 35 (d) (ii)

Criteria	Marks
• Explains why the trend is unlikely to continue	3
• Outlines one reason OR • Identifies reasons	2
• Identifies a reason	1

Sample answer:

There is a limit to miniaturisation of components (unlikely to produce a component smaller than an atom). Chips may not continue to grow larger due to heat effects and connections.

Answers could include:

- The need to consider quantum effects as component size decreases because of tunneling of electrons through components.
- Rather than building bigger and faster linear-processing computers, designers rarely develop newer computers (ie conceptualised).

Question 35 (e)

Criteria	Marks
• Provides applications of transducers • Makes an informed judgement explicitly/implicitly of the impact on society of these application • Supports answer with one input and one output transducer	6
• Provides applications of transducers • Outlines the positive and/or negative effects of these applications on society • Supports answer with one input and one output transducer	5
• Identifies at least one transducer and its application(s) • Outlines the positive and/or negative effects of the application(s) on society	4
• Identifies transducer(s) and/or their application(s) and/or their impact(s) on society	2–3
• Provides some relevant information	1

Sample answer:

Transducers are used in most electron circuits and have a significant impact on most areas of society, as shown in the examples below.

Solar cells (input transducers) convert solar energy to electricity, which may then be used in these circuits. This reduces the demand on coal-fired electricity production which reduces CO_2 production which benefits society through reducing global warming risks.

Solar-generated electricity can be used in remote locations where the grid is not available, improving the quality of life of people thereby giving them access to communications technologies.

Current meters (output transducers) detect and show the current in a circuit to be viewed (by a decision maker) or connected to another circuit (control system). This potentially results in increased safety or more efficient control of systems.

2015 HSC Physics Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.3.1.3.5	H9
2	1	9.4.4.2.1	H8
3	1	9.4.1.3.2	H10, H14.1b
4	1	9.2.2.2.1	H6
5	1	9.4.4.2.4	H9, H10
6	1	9.2.4.3.4	H2
7	1	9.3.1.3.3, 13.1(f)	H9
8	1	9.4.1.3.3	H9
9	1	9.3.1.3.1	H9
10	1	9.4.3.2.6	H10
11	1	9.2.2.2.8	H6
12	1	9.3.2.3.2	H7
13	1	9.4.3.2.2	H10
14	1	9.2.4.3.2	H6
15	1	9.3.2.2.4	H9
16	1	9.2.4.2.10	H6
17	1	9.4.2.2.3/4	H10
18	1	9.3.4.2.3, 9.3.2.2.4/5	H9
19	1	9.2.2.2.8	H6
20	1	9.2.2.3.1	H6

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	2	9.2.2.2.1, 13.1f, 13.1g	H13
21 (b)	2	9.2.2.3.1, 14.1f	H6, H14
22 (a)	3	9.3.1.3.3	H9
22 (b)	2	9.3.1.2.3/5/6	H6, H9
23 (a)	3	9.4.3.3.1	H10
23 (b)	2	9.4.3.3.1 14.1f	H10, H14
24 (a)	3	9.4.1.2.9	H9
24 (b)	2	9.4.1.3.3	H9
24 (c)	2	9.2.2.3.1	H9
25 (a)	3	9.3.5.3.2	H7
25 (b)	3	9.3.4.2.4	H7, H12.4(d)
26 (a)	2	9.2.1.2.2	H9, H14.1(f)
26 (b)	1	9.2.1.2.2 14.1f	H9, H14

Question	Marks	Content	Syllabus outcomes
26 (c)	3	9.2.2.2.10, 3.4	H6, H9
27	6	9.4.2.2.2	H2, H8
28	5	9.3.2.3.4, 2.7	H7, H9
29 (a)	2	9.4.4.2.7, 9.4.4.2.3, 9.2.4.2.9	H9
29 (b)	3	9.2.4.2.9, 9.2.4.2.4	H6
30	6	9.2.3.2.4/3, 9.2.2.2.8	H6

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Geophysics**	
(a) (i)	2	9.5.1.3.2	
(a) (ii)	3	9.1 11.2c	H2, H11
(b) (i)	2	9.5.4.2.2	H9
(b) (ii)	3	9.5.4.2.1, 9.5.4.2.2	H9
(c)	4	9.5.2.2.4, 9.5.2.2.5	H9
(d) (i)	2	9.1, 14.1a	H14
(d) (ii)	3	9.5.3.3.2, 9.5.3.2.2, 9.5.3.2.3	H8
(e)	6	9.5.2.2.2	H4, H14
Question 32		**Medical Physics**	
(a) (i)	2	9.6.1.3.1	H8
(a) (ii)	3	9.6.1.3.5	H8, H13, H14
(b) (i)	2	9.6.2.2.1, 9.6.3	H8, H10
(b) (ii)	3	9.6.3.2.5, 9.6.4.3.4	H10, H14
(c)	4	9.6.2.2.5, 9.6.2.2.6	H8
(d) (i)	2	9.6.4.3.2	H7, H9
(d) (ii)	3	9.6.4.2.5, 9.6.4.2.6, 9.6.4.2.7	H8, H9, H14
(e)	6	9.6	H1, H8
Question 33		**Astrophysics**	
(a) (i)	2	9.7.4.3.1	H14
(a) (ii)	3	9.7.2.2.2, 9.7.4.2.3, 9.7.5.2.4	H8
(b) (i)	2	9.7.5.3.1	H6, H8
(b) (ii)	3	9.7.5.2.1	H8
(c)	4	9.7.3.2.1, 9.7.3.2.3	H8, H10
(d) (i)	2	9.7.3.3.2, 9.7.6.3.2	H8
(d) (ii)	3	9.7.6.2.2, 9.7.6.2.3, 9.7.6.3.2	H9
(e)	6	9.7.1.2.3, 9.7.1.3.1, 9.7.3, 9.7.4.2.4/5	H1
Question 34		**From Quanta to Quarks**	
(a) (i)	2	9.8.3.3.1	H7, H9
(a) (ii)	3	9.8.3.3.2	H7, H10, H13
(b) (i)	2	9.8.2.3.1	H10, H13

Question	Marks	Content	Syllabus outcomes
(b) (ii)	3	9.8.4.2.3	H8, H10
(c)	4	9.8.1.3.1, 9.8.1.2.2	H1, H7, H8
(d) (i)	2	9.8.2.2.3	H10
(d) (ii)	3	9.8.1.3.4	H7, H8
(e)	6	9.8.3.2.7, 9.8.3.2.8, 9.8.3.3.2	H7, H9
Question 35		**The Age of Silicon**	
(a) (i)	2	9.9.5.2.1/3.1	H7
(a) (ii)	3	9.9.5.2.1/3.2	H7
(b) (i)	2	9.9.2.3.3	H7, H9
(b) (ii)	3	9.9.3.2.6	H7
(c)	4	9.9.6.2.10/3.5	H7
(d) (i)	2	9.9.1.2.2	H7
(d) (ii)	3	9.9.7.2.1/2, 9.9.7.3.1	H5
(e)	6	9.9.1.3.1	H4