PEM

Professional Educational Materials

Student Number

2023 HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided

Total marks: 100

Section I – 20 marks (pages 2–8)

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

Section II – 80 marks (pages 9–22)

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

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

Use the multiple choice answer sheet for Questions 1-20

---

1 What evidence confirms de Broglie's theory?

(A) The double-slit experiment with electrons.

(B) The photoelectric effect.

(C) The Franck-Hertz experiment.

(D) The Millikan oil drop experiment.

2 Which of the following statements is true about the direction of the magnetic force on a charged particle moving in a magnetic field?

(A) The force is in the direction of the magnetic field.

(B) The force is perpendicular to the magnetic field and the velocity of the charged particle.

(C) The force is in the direction opposite to the magnetic field.

(D) The force is in the direction of the velocity of the charged particle.

3 Why do transformers only use AC voltage?

(A) DC voltage is too dangerous to use with transformers.

(B) AC voltage is easier to generate than DC voltage.

(C) The magnetic field in the transformer needs to be constantly changing to induce a current in the secondary coil.

(D) AC voltage is more efficient than DC voltage for transferring energy between coils.

4 Which of the following best describes the evidence found by Hubble to suggest an expanding universe?

(A) Observation of redshifts in the spectra of distant galaxies.

(B) Observation of blueshifts in the spectra of nearby galaxies.

(C) Observation of Cephid variables showing that galaxies were much further away than previously believed.

(D) Observation of redshifts dominating the spectra of observable galaxies.

5 Why was the relationship $E = mc^2$ such a controversial idea when it was first released in 1905?

(A) It contradicted the principle of conservation of mass.

(B) It contradicted the principle of conservation of energy.

(C) It went against the current understanding of the laws of physics.

(D) It had no experimental evidence to support it.

6 Which of the following observations of the photoelectric effect did not challenge the wave model of light?

(A) Photoelectrons were only ejected if the incident electromagnetic radiation was above a set value.

(B) Emission of photoelectrons is instantaneous.

(C) Increase in the intensity of the electromagnetic radiation used will result in a larger photocurrent.

(D) Photocurrent has a maximum value with increasing light intensity.

7 How do cosmic-origin muons validate special relativity?

(A) By measuring the time dilation effect caused by their high speeds and verifying the predictions of special relativity.

(B) By demonstrating the concept of length contraction and confirming the predictions of special relativity.

(C) By measuring the relativistic mass increase of the muons as they travel at high speeds.

(D) By observing the deflection of the muons in magnetic fields, which can only be explained by the effects of special relativity.

8 Which of the following best explains why circular tracks are banked?

(A) To increase the centripetal force required to keep the object moving in a circle.

(B) To decrease the centripetal force required to keep the object moving in a circle.

(C) To increase the gravitational force acting on the object.

(D) To decrease the frictional force acting on the object perpendicular to the direction of motion.

9 Which of the following statements correctly describes how particle accelerators increase the velocity of charged particles?

(A) Charged particles are accelerated by applying a large magnetic field perpendicular to the path of the particle.

(B) Charged particles are accelerated by collisions with high-energy photons.

(C) Charged particles are accelerated by passing through a series of alternating electric fields.

(D) Charged particles are accelerated by being heated to extremely high temperatures.

10 Which of the following is a limitation of the Bohr model of the atom?

(A) It cannot explain the observed line spectra of atoms with more than one electron.

(B) It cannot account for the quantization of angular momentum in atoms.

(C) It cannot predict the correct value of the ground state energy for hydrogen.

(D) It does not consider the wave-particle duality of electrons.

11 A transformer used to step down the voltage of an AC power source from 240 V to 12 V has an input current of 10 A. If the primary coil has 300 turns, how many turns are in the secondary coil?

(A) 15

(B) 20

(C) 24

(D) 40

12 Two point charges of 3.0×10^{-6} C and -5.6×10^{-16} C are separated by a distance of 0.10 m. What is the magnitude of the electric force between them?

(A) 8.1×10^{-10} N

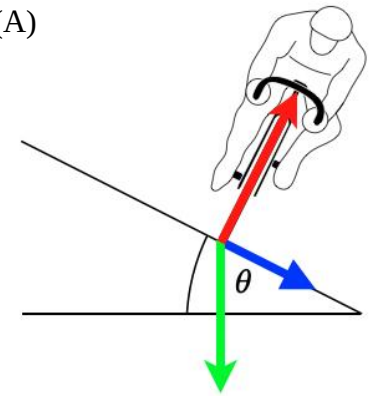
(B) 1.5×10^{-9} N

(C) 2.7×10^{-9} N

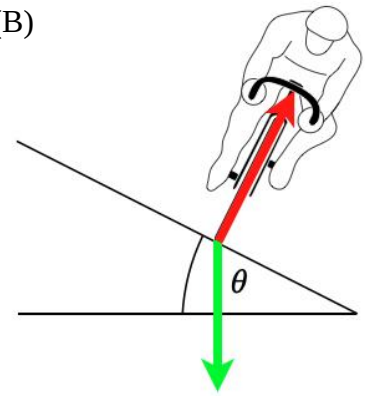
(D) 5.4×10^{-9} N

13 A cyclist is riding around a corner on a banked track. He is travelling faster than the design speed of the bank. Which of the following vector diagrams illustrates the forces acting on the cyclist?

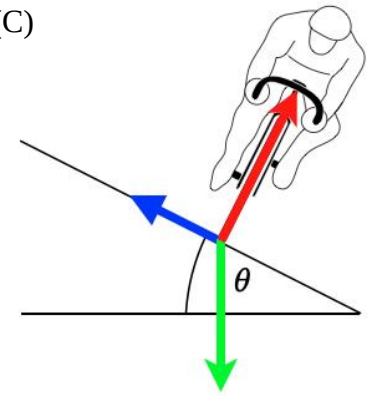
(A)



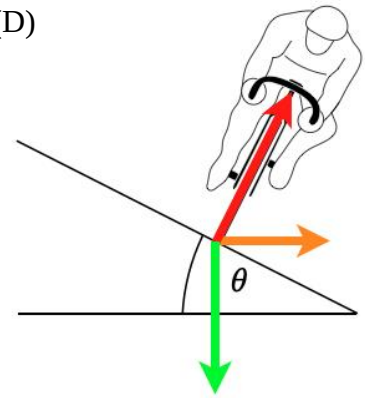
(B)



(C)



(D)



14 Which statement correctly matches Malus' Law?

(A) The intensity of polarised light entering an analyser is directly proportional to the cosine squared of the angle between the polariser and the analyser.

(B) The intensity of polarised light entering an analyser is inversely proportional to the cosine squared of the angle between the polariser and the analyser.

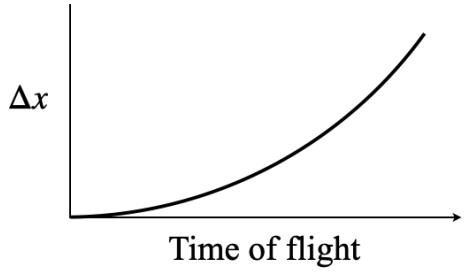
(C) The intensity of non-polarised light entering an analyser is directly proportional to the cosine squared of the angle between the polariser and the analyser.

(D) The intensity of a non-polarised light entering an analyser is inversely proportional to the cosine squared of the angle between the polariser and the analyser.

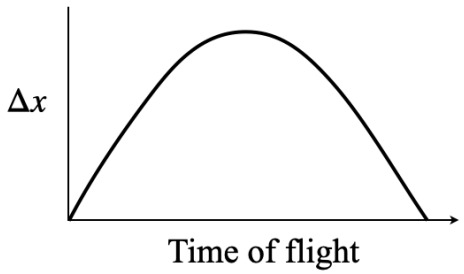
15 A student undertook a depth study to collect data to validate the relationship between launch angle and time of flight for a projectile. The student shot the projectile through a range of angles with a consistent launch velocity. Using the collected data, the student accidently graphed the range versus time of flight.

Which of the following would correctly show the accidental graph?

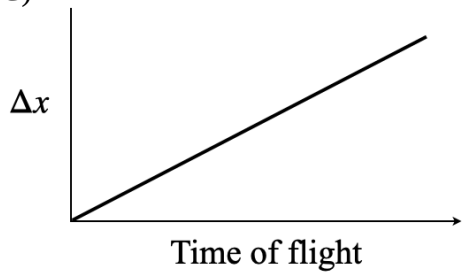
(A)



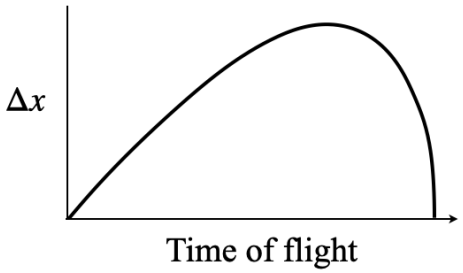
(B)



(C)



(D)



16 Which of the following configurations of quarks is correct for protons and neutrons?

	Proton	Neutron
(A)	uud	udd
(B)	udd	uud
(C)	ddd	uuu
(D)	uuu	ddd

17 Which of the following statements is true regarding the observations of two people, one traveling at the speed of light, and one stationary?

(A) Both people will observe time to be passing at the normal rate.

(B) The person traveling at the speed of light will observe time to be passing slower.

(C) The stationary person will observe time to be passing slower.

(D) Both people will observe time to be passing faster than each other.

18 A large warehouse ceiling fan has blades 1.5 m in length that rotate so the tips of the blade travels a distance of 2.5 m in 0.5 s. At what angular velocity does the turbine rotate?

(A) $72^\circ\ s^{-1}$

(B) $92^\circ\ s^{-1}$

(C) $120^\circ\ s^{-1}$

(D) $191^\circ\ s^{-1}$

19 A wire of length 0.5 m is moved through a magnetic field of 0.1 T at a speed of 2.0 m s^{-1}. If the angle between the wire and the magnetic field is 90 degrees, what is the emf induced in the wire?

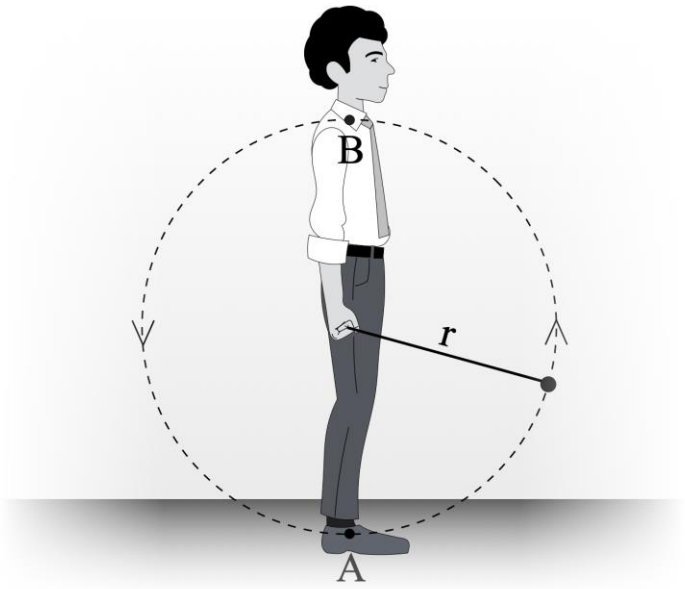
(A) 0.05 V

(B) 0.10 V

(C) 0.20 V

(D) 0.40 V

20 A man is spinning a weight on the end of a string in a circle as shown in the image below.



If the circle has a radius of r, what expression shows the change in velocity from point A to point B.

(A) $\frac{-4gr}{v+u}$

(B) $\sqrt{4gr}$

(C) $\frac{2\pi r}{2g}$

(D) $\sqrt{2gr}$

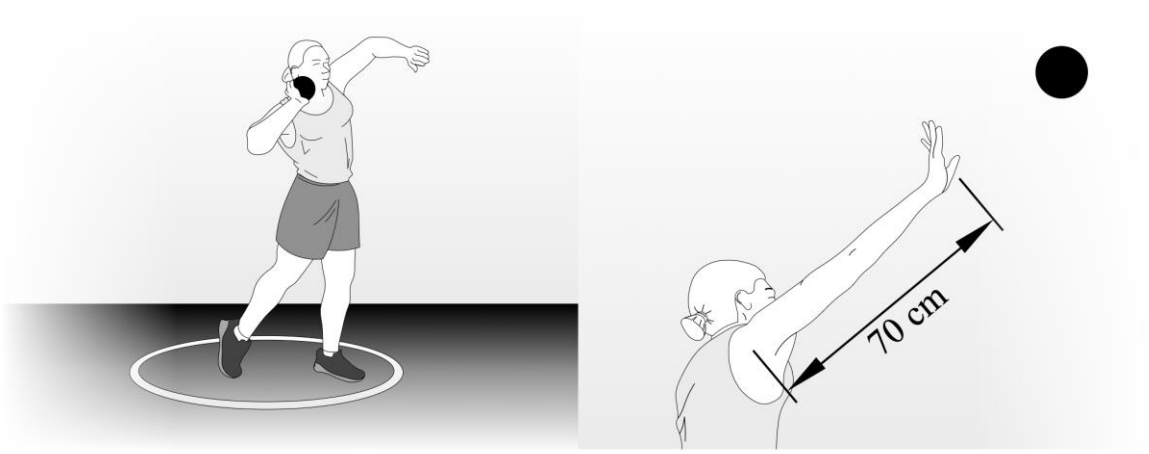
Part B – 80 marks
Attempt questions 21-36
Allow about 2 hour and 25 minutes for this part

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.

Question 21 (11 marks)

A champion shot put thrower is competing in a competition despite having recently damaged a ligament in her knee. Because of her injury she is forced to throw the shot put from a static position. Therefore, the shotput will only be accelerated across the distance of her extended arm which is 70 cm long.



(a) During her first attempt, she applied a constant force of 431 N throughout the extension of her arm. If the 4.0 kg ball is released at 12 m s^{-1}, at what angle did she throw the ball? **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

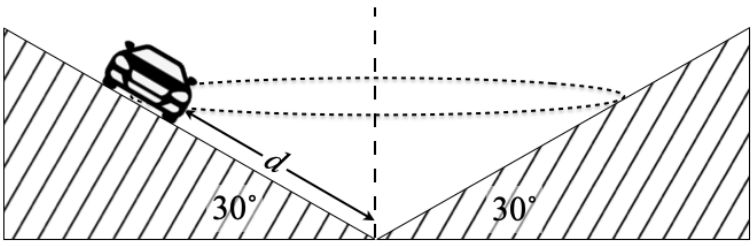
Question 21 continues on page 10

(b) On her second attempt she releases the shot put at an angle of 45˚ with the same launch velocity as her first attempt in part (a). If she released it from a height of 2 m above the ground, determine the range of her throw. **4**

(c) The athlete has a limited understanding of projectile motion and always thought that to achieve a maximum horizontal distance the optimal angle of launch was 45˚. Explain why in this instance this is not the case. **3**

Question 22 (4 marks)

A car is travelling around a circular banked track as shown in the diagram below.



In order to complete the required laps with the fastest time, the driver wants to reduce the amount of friction acting up or down the slope. For a speed of 110 km h^{-1}, at what distance *d* should the driver locate his car to maintain a circular path and minimise friction?

Question 23 (2 marks)

The total energy in a non-constant gravitational field is $E = K + U$.

Show that $E = -\frac{GMm}{2r}$

Question 24 (3 marks)

How does Kepler's third law of planetary motion describe the relationship between a planet's orbital period and its distance from the sun?

Question 25 (3 marks)

Describe the energy transfers and transformations that occur in an electric motor.

Question 26 (3 marks)

An electron at rest is accelerated to 1.28×10^7 m s^{-1} by two parallel electric plates. Calculate the potential difference of the plates.

Question 27 (6 marks)

(a) Describe how back EMF is generated in a DC motor, and how it affects the motor's performance. **3**

(b) Explain how the use of back EMF can be utilized to control the motor's speed. **3**

Question 28 (8 marks)

(a) Discuss the qualitative limitations of the ideal transformer model, and how they affect its applicability to real-world situations. **4**

(b) In terms of change in flux, explain why more turns in a secondary coil equates to higher voltages. **4**

Question 29 (3 marks)

How did Maxwell's prediction of the velocity of electromagnetic waves contribute to the classical theory of electromagnetism?

Question 30 (9 marks)

(a) Explain how discharge tubes with different gases can produce different spectra. **3**

Question 30 continues on page 17

(b) What is the relevance of spectra produced by discharge tubes to the spectral analysis of stars? **2**

(c) Explain how spectra from stars can reveal its rotational velocity. **4**

Question 31 (6 marks)

Outline qualitatively how Thomas Young's double slit experiment supported a wave model of light and describe the quantitative measurements that could be deduced from the results.

Question 32 (3 marks)

Students used a popular online photoelectric cell simulator to observe the effect of changing the frequencies and intensities of incident light. The students noticed that the emitted photoelectrons did not all have the same velocities as they travelled across the discharge tube despite all receiving the same frequency of incident light. Account for this observation.

Question 33 (4 marks)

Explain how certain elements of the Geiger-Marsden experiment results supported the current model of the atom at the time and how certain elements suggested that it was insufficient.

Question 34 (3 marks)

In the early 20th century Ejnar Hertzsprung and Henry Norris Russel independently began investigating the relationship between the temperature and luminosity of visible stars. Assess the significance of this investigation.

Question 35 (6 marks)

Describe the possible life cycles for a main sequence star and explain how they relate to their initial starting point on the main sequence.

Question 36 (6 marks)

Account for the energy production throughout the proton-proton chain and explain why it does not violate the law of conservation of energy.

END OF EXAM

BLANK PAGE

PEM

2023 Trial HSC Physics Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21 (a)

Criteria	Marks
Correctly calculates the angle	C
Correctly calculates the change in height	3
Attempts to determine the GPE	2
Attempts to solve using correct work formulas	1

Sample answer:

$W = Fs = \Delta E_K + \Delta(-GPE)$

$Fs = \frac{1}{2}mv^2 - mg\Delta h$

$\Delta h = \frac{{}^1/_2 mv^2 - Fs}{mg}$

$\Delta h = \frac{{}^1/_2 \times 4 \times 12^2 - 431 \times 0.7}{4 \times -9.8}$

$\Delta h = 0.35\ m$

$\theta = \sin^{-1}\left(\frac{0.35}{0.7}\right)$

$\theta = 30^\circ$

Question 21 (b)

Criteria	Marks
Correctly calculates the range	4
Correctly calculates the time of flight	3
Correctly calculates components of initial velocity	2
Attempts to use equation of motion	1

Sample answer:

$\Delta s = u_y t + \frac{1}{2} a t^2$

$\frac{1}{2} a t^2 + u_y t - \Delta s = 0$

$t = \frac{-u_y \pm \sqrt{{u_y}^2 - 4\left(\frac{1}{2} a \times -\Delta s\right)}}{a}$

$t = \frac{-12 \cos 45 \pm \sqrt{(12 \cos 45)^2 - 4(-4.9 \times 2)}}{-9.8}$

$t = 1.94 \text{ s}$

$\Delta x = u_x t$

$\Delta x = 12 \cos 45 \times 1.94$

$\Delta x = 16.5 \text{ m}$

Question 21 (c)

Criteria	Marks
Clearly articulates why 45˚ is not the optimal angle.	3
Identifies that the launch is from a height and describes that the launch angle will need to be less than 45˚.	2
Identifies that the launch is from a height.	1

Sample answer:

When a projectile is launched from a height, such as in this scenario, 45˚ is not the optimum angle of launch. When the projectile has reached a change in displacement of zero, the projectile must still fall through the vertical distance of the height of launch. A projectile launched at 45˚at this point will have the longest range, but a greater vertical component and a smaller horizontal component compared to smaller angles. It will therefore travel the remaining distance faster and with a smaller horizontal velocity than a lower angle projectile. If the remaining vertical distance is long enough the projectile launched at a smaller angle may travel a longer distance than the difference of range at the zero displacement mark. This means that 45˚ is not the optimal angle when launched from a height.

Question 22

Criteria	Marks
Correctly calculates distance	4
Correctly calculates the radius and makes a trigonometric error calculating the distance	3
Correctly calculates the radius	2
Attempts to calculate the radius	1

Sample answer:

$\tan\theta = \frac{\Sigma F}{F_g}$

$\tan\theta = \frac{mv^2}{mgr}$

$\tan\theta = \frac{v^2}{gr}$

$r = \frac{v^2}{g\tan\theta}$

$r = \frac{30.6^2}{9.8\tan 30}$

$r = 165$ m

$d = \frac{r}{\cos\theta}$

$d = \frac{165}{\cos 30}$

$d = 191$ m

Question 23

Criteria	Marks
Correctly derives total energy using kinetic energy and gravitational potential formulas	2
Starts correct derivation using kinetic energy and gravitational potential formulas	1

Sample answer:

$F_g = F_c$

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

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

$\frac{GMm}{2r} = \frac{1}{2}mv^2 = K$

$E = K + U = \frac{GMm}{2r} - \frac{GMm}{r}$

$E = -\frac{GMm}{2r}$

Question 24

Criteria	Marks
Describes the relationship between a planet's orbital period and its distance from the sun according to Kepler's third law qualitatively and quantitatively.	3
Describes the relationship between a planet's orbital period and its distance from the sun according to Kepler's third law qualitatively and identifies the formula.	2
Describes the relationship between a planet's orbital period and its distance from the sun according to Kepler's third law qualitatively or quantitatively.	1

Sample answer:

Kepler's third law of planetary motion states that the square of the orbital period of a planet is proportional to the cube of its average distance from the sun. This means that if the distance of a planet from the sun is doubled, its orbital period will increase by a factor of approximately 2.8 (the cube root of 2^3), and if the distance is tripled, the orbital period will increase by a factor of approximately 4.2 (the cube root of 3^3), and so on. This law also implies that planets that are farther from the sun have longer orbital periods than those that are closer to the sun, and that the relationship between a planet's distance from the sun and its orbital period is a fundamental characteristic of the solar system.

Question 25

Criteria	Marks
Describes the most significant energy transfers and transformations in an electric motor.	3
Describes some significant energy transfers and transformations in an electric motor.	2
Describes a significant energy transfers or transformations in an electric motor.	1

Sample answer:
The energy transformations usually start with the power source, which has electrical potential energy. This energy is transformed into electrical energy when it flows through the motor. The electrical energy is transformed into mechanical energy as a result of the motor effect, when the magnetic field in the coil interacts with the magnets magnetic field. This mechanical energy is then transferred to the shaft of the motor, which drives a load or performs work. The electrical energy is also transformed into heat energy because of resistance in the coils. Inefficiencies in the system, such as friction, during the rotation will cause further energy transformations such as Mechanical energy to heat energy.

Question 26

Criteria	Marks
Correctly calculates the potential difference	3
Uses correct formulas with substitution error	2
Attempts to use Work formula or kinetic energy formula	1

Sample answer:

$W = qV = \Delta E$

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

$V = \frac{mv^2}{2q}$

$V = \frac{9.109\times10^{-31}\times\left(1.28\times10^{7}\right)^2}{2\times1.602\times10^{-19}}$

$V = 466\,V$

Question 27 (a)

Criteria	Marks
Explains the production of back EMF and describes its effect on the motor's performance.	3
Explains the production of back EMF	2
Describes back EMF or describes its effect on the motor's performance.	1

Sample answer:

When a DC motor is powered, the magnetic field from motor's stator interacts with the magnetic field produced by the rotor and creates a rotational force. However, when the rotor starts to rotate a current is induced in the coil according to Faraday's law. Lenz's law dictates that this induced current will produce a magnetic field that opposes the change in magnetic field that produced it. This current, known as back EMF is generated in the opposite direction to the voltage applied to the motor.
The magnitude of the back EMF generated in a DC motor is proportional to the speed of the motor. Firstly, it limits the current drawn by the motor, which helps to prevent the motor from overheating or burning out. Secondly, it reduces the torque produced by the motor at high speeds, which means that the motor may not be able to produce enough torque to maintain its speed under heavy loads.

Question 27 (b)

Criteria	Marks
Describes how back EMF is calculated, how it relates to speed, and identifies how the speed is controlled.	3
Describes how back EMF is calculated, how it relates to speed.	2
Describes how back EMF is calculated or how it relates to speed.	1

Sample answer:

The potential difference across the armature (V_m) can be easily measured, and the back EMF (E_b) calculated using $E_b = V_s - V_m$, where V_s is the supplied voltage. Because back EMF is proportional to motor speed, the back EMF can be used as a feedback signal to determine the motor's speed. The speed can be easily calculated using the motors constant of proportionality between the motor's speed and the back EMF. Adjustments can then be made to the supplied voltage to maintain the desired speed even when different loads are applied.

Question 28 (a)

Criteria	Marks
Describes the ideal transformer model and its limitations and links to an assessment of its applicability.	4
Describes a limitation of the ideal transformer model and links to an assessment of its applicability.	3
Describes the ideal transformer model and its limitations.	2
Describes a limitation of the ideal transformer model.	1

Sample answer:

The ideal transformer model is a theoretical construct that provides a simplified representation of the behaviour of transformers in ideal conditions. The ideal transformer model assumes perfect coupling between the primary and secondary windings, which means that all the magnetic flux generated by the primary winding links with the secondary winding. Realistically, there are always some flux losses due to leakage or fringing effects, which means that the actual transformer efficiency can be lower than predicted by the ideal transformer model.
The ideal transformer model also does not account for the effects of parasitic elements, such as winding resistance and capacitance, as well as the non-ideal characteristics of magnetic materials used in the transformer's core.
These losses can significantly affect the efficiency and performance of the transformer.
In practice, transformers must be designed to account for these limitations and to ensure that they perform as expected under a range of operating conditions, implying that the ideal transformer model has limited applicability in real-world situations.

Question 28 (b)

Criteria	Marks
Clearly explains why, in terms of change in flux, increased turns equate to more induced voltage.	4
Attempts to explain why, in terms of change in flux, increased turns equate to more induced voltage.	3
Describes the turn ratio equation with reference to change in flux	2
Describes the turn ratio equation	1

Sample answer:

The magnetic flux linking the primary and secondary coils of a transformer is the same, as they share the same iron core. Therefore, the rate of change of magnetic flux experienced by each turn of the secondary coil is directly proportional to the number of turns in the coil.
When we increase the number of turns in the secondary coil, we are effectively increasing the amount of wire that is exposed to the changing magnetic field. This means that each turn of wire in the secondary coil experiences the same change in magnetic flux per unit of time, but there are more turns of wire exposed to this changing magnetic flux.
Thus, by increasing the number of turns in the secondary coil, we are increasing the rate of change of magnetic flux that cuts across each turn of the coil. This leads to a higher induced voltage in the secondary coil, as the rate of change of magnetic flux experienced by each turn of wire is the same, but there are more turns of wire exposed to this changing magnetic flux.

Question 29

Criteria	Marks
Identifies Maxwell's prediction and links it to its contribution to the classical theory of electromagnetism.	3
Identifies Maxwell's prediction and identifies the classical theory of electromagnetism.	2
Identifies Maxwell's prediction	1

Sample answer:

Maxwell's prediction of the velocity of electromagnetic waves was based on his equations that described the behaviour of electric and magnetic fields. These equations showed that electromagnetic waves travelled at a constant speed, which was determined by the electric and magnetic properties of the medium through which they were propagating. The speed is equal to the speed of light in a vacuum. this prediction showed that electricity and magnetism were related and interdependent, forming a fundamental force of nature called electromagnetism. The speed he identified matched the current known speed of light. This suggested that light was a form of electromagnetic radiation. This was a key prediction that unified the fields of electricity and magnetism and formed the basis for the classical theory of electromagnetism.

Question 30 (a)

Criteria	Marks
Identifies the different energy levels present in different elements or molecules and relates these to their emitted spectra.	3
Identifies the different energy levels present in different elements or molecules and relates these to their emitted wavelengths.	2
Identifies the different energy levels present in different elements or molecules	1

Sample answer:

The emission spectrum of a gas is produced when its atoms or molecules absorb energy and then release it as light. When the electrical current is passed through the gas-filled discharge tube, the gas atoms are excited to a higher energy level. As they return to their ground state, they release energy in the form of light, which is emitted from the tube.
Each gas has its unique set of energy levels, and therefore, it can only emit light at certain wavelengths. This difference in energy levels is due to the different electron configurations of the atoms in the gas, which are determined by the number of protons and neutrons in the nucleus and the arrangement of electrons around it. When the light emitted from the gas is analysed using a spectrometer, it produces a pattern of lines at specific wavelengths, which is known as the emission spectrum.

Question 30 (b)

Criteria	Marks
Describes how discharge tubes spectra are related to the spectral analysis of stars	2
Identifies how discharge tubes spectra are related to the spectral analysis of stars	1

Sample answer:

When the light from a star is passed through a prism, it produces a continuous spectrum with dark lines called absorption lines. These absorption lines correspond to the wavelengths of light that are absorbed by the elements in the star's atmosphere.
By comparing the absorption lines in a star's spectrum to the emission lines produced by known elements in discharge tubes, scientists can identify which elements are present in the star's atmosphere.

Question 30 (c)

Criteria	Marks
Relates rotation to Doppler shift and describes how it is manifested on a spectrum and interpreted.	4
Relates rotation to Doppler shift and describes how it is manifested on a spectrum.	3
Relates rotation to Doppler shift.	2
Identifies how rotation is manifested on a spectrum.	1

Sample answer:

When a star is rotating, one side of it is moving towards us and the other side is moving away from us. This causes a Doppler shift in the star's spectral lines. The spectral lines on the side of the star that is moving towards us are shifted to shorter wavelengths (blueshifted) and the spectral lines on the side of the star that is moving away from us are shifted to longer wavelengths (redshifted). This causes a broadening of the spectral absorption lines. The greater the rotational velocity, the greater the broadening. By measuring the amount of broadening astronomers can determine the star's rotational velocity.

Question 31

Criteria	Marks
Describes the results of the double slit experiment and explains how this supported a wave model and was not consistent with a particle model. And Describes the relationships between variables in the experiment that enabled measurements to be calculated.	5-6
Describes the results of the double slit experiment, And Describes the relationships between variables in the experiment	3-4
Identifies the results of the double slit experiment, And Identifies the measurements that could be deduced from the results	1-2

Sample answer:

Qualitatively, Thomas Young's double slit experiment showed that light could behave like a wave, by creating an interference pattern on a screen behind the two slits. The pattern consisted of alternating bright and dark fringes, which could only be explained if light waves from the two slits interfered with each other constructively at some points, and destructively at others. This pattern could not be explained by a corpuscular theory of light, which would predict that light should travel in straight lines and produce two bright spots on the screen behind each slit.

Quantitatively, the experiment provided a way to measure the wavelength of light. By measuring the distance between the bright fringes on the screen and the distance between the slits, Young was able to determine the wavelength of the light being used. This was possible because the bright fringes on the screen were created when the waves from the two slits interfered constructively, creating a maximum. The distance between each bright fringe (Δy) was related to the distance between the slits (d) and the wavelength of light (λ) by the equation: $\Delta y = \frac{\lambda D}{d}$.

Additionally, the experiment also provided a way to measure the distance between the slits. By observing the interference pattern on the screen, it was possible to determine the distance between the slits that created the pattern. This measurement was important because it allowed Young to calculate the distance between the fringes on the screen and, thus, the wavelength of light.

Question 32

Criteria	Marks
Explains the energy loss of electrons emitted from different depths on the surface.	3
Identifies electrons emitted from different depths on the surface experiencing energy loss.	2
Identifies electrons emitted from different depths on the surface or identifies electrons with different initial energies.	1

Sample answer:

Photoelectrons emitted from a cathode can come from different depths on the surface. The electrons that are emitted from deeper layers of the cathode will need to travel through more layers of the material before reaching the surface, and they will lose some of their energy due to collisions with other electrons or atoms along the way. Therefore, they will have a lower initial kinetic energy and hence a lower ejection velocity compared to electrons emitted from shallower layers.

Question 33

Criteria	Marks
Explains the supporting and contradictory evidence of the Geiger-Marsden experiment to the Thomson model of the atom.	4
Explains the supporting and some of the contradictory evidence of the Geiger-Marsden experiment to the Thomson model of the atom.	3
Describes the supporting and contradictory evidence of the Geiger-Marsden experiment to the Thomson model of the atom.	2
Describes the supporting or contradictory evidence of the Geiger-Marsden experiment to the Thomson model of the atom.	1

Sample answer:

One element of the Geiger-Marsden experiment results that supported the current Thomson model was that most of the alpha particles passed straight through the gold foil without being deflected at all. This was expected according to the Thomson model, as the positive charge in the atom was thought to be uniformly distributed, so the alpha particles should pass through without significant deflection.
However, a small fraction of the alpha particles were deflected at large angles, indicating that they had come very close to a positively charged nucleus. This result was unexpected according to the Thomson model. the deflection of the alpha particles at large angles suggested that the atom had a small, positively charged nucleus at its centre and that the current model was insufficient.
Furthermore, the Geiger-Marsden experiment results also suggested that the nucleus was much smaller than the size of the atom, which was inconsistent with the Thomson model. This was because the vast majority of the alpha particles passed straight through the gold foil without significant deflection, indicating that the nucleus must be small and concentrated to allow so many particles to pass through.

Question 34

Criteria	Marks
Assesses the significance of Hertzsprung and Russell's investigation to astronomy with justifications.	3
Assesses the significance of Hertzsprung and Russell's investigation to astronomy with a justification.	2
Outlines what deductions were made from the H-R diagram	1

Sample answer:

Hertzsprung and Russell discovered that stars could be grouped into different categories based on their luminosity and temperature. This discovery allowed astronomers to classify stars into distinct groups based on their physical properties. By studying the properties of stars across the Hertzsprung-Russell diagram, which is a direct result of their investigation, astronomers were able to gain insights into the physical processes that govern how stars evolve over time. Their investigation was hugely influential to the field of astronomy as it gave an unprecedented insight into the inner working of stars and their evolution.

Question 35

Criteria	Marks
Describes the main life cycles of main sequence stars and links to starting position through their mass.	5-6
Describes some life cycles of main sequence stars and links to starting position through their mass.	3-4
Describes a life cycles of main sequence stars and links to starting position through their mass.	1-2

Sample answer:

Less massive stars, such as red dwarfs, have lower core temperatures and pressures, which means they burn through their hydrogen fuel more slowly and release less energy. This results in a lower luminosity and a lower surface temperature, which places them in the lower-right portion of the main sequence on the HR diagram. Because of their lower gravitational forces, convection cells can form and drag helium outward from the core and replace it with hydrogen from the outer layers. As a result, a red dwarf can essentially consume all its hydrogen whilst on the main sequence. Without the gravitationally forces necessary to fuse helium, it will then cease nuclear fusion and become a white dwarf.
Intermediate-mass stars burn hydrogen more quickly than low-mass stars. After they exhaust the hydrogen in their cores, they expand into red giants and eventually shed their outer layers to form planetary nebulae. The remaining core becomes either a white dwarf or a neutron star. A neutron star is a result of having a larger mass to collapse in on itself following the end of fusion.
More massive stars have higher core temperatures and pressures, which allows them to burn through their hydrogen fuel faster and release more energy. This results in a higher luminosity and a higher surface temperature, which places them in the upper-left portion of the main sequence on the HR diagram.
After they exhaust the hydrogen in their cores, they expand into red supergiants and undergo a supernova explosion. The remaining core becomes either a neutron star or a black hole. Each of these transitions is a direct result of their very large mass.

Question 36

Criteria	Marks
Explains the energy production at the three stages of the proton-proton chain and explain why it does not violate the law of conservation of energy.	5-6
Explains the energy production at two stages of the proton-proton chain and explain why it does not violate the law of conservation of energy.	3-4
Explains the energy production at one of the stages of the proton-proton chain and explain why it does not violate the law of conservation of energy. Or Explains why the law of conservation of energy is not violated and identifies forms of energy produced.	1-2

Sample answer:

When two protons fuse to form a deuterium nucleus a positron and a neutrino are emitted. The mass defect of this reaction is converted to energy according to $E = mc^2$. This ensures that the conservation of energy is not violated. This energy is released as kinetic energy of the emitted positron and neutrino. The positron and an electron in the plasma will then annihilate each other, and their masses will be converted into more energy, according to $E = mc^2$. This energy is emitted as high energy gamma rays.

The deuterium nucleus fuses with another proton to form a helium-3 nucleus. The helium-3 nucleus that is formed is in an excited state. The excited state is a result of stored potential energy from the mass defect of this reaction. The conversion of mass to energy according to $E = mc^2$again justifies this. To return to its ground state, the helium-3 nucleus must release the excess energy in the form of high energy gamma rays.

Finally, two helium-3 nuclei fuse to form a helium-4 nucleus and two protons. This reaction also presents a large mass defect. The energy produced according to $E = mc^2$ is mostly released as gamma rays. Some energy remains as kinetic energy in the nucleus, which may transfer to surrounding particles leading to an increase in temperature.

Overall, the fusion reactions in the proton-proton chain convert small amounts of mass into energy, as described by Einstein's equation $E = mc^2$. This energy is released in the form of gamma rays, kinetic energy, and eventually, thermal energy. In this way the law of conservation of energy is not violated.

Physics

2023 Trial HSC Examination Mapping Grid

Part A

Question	Marks	Outcome
1	1	PH12-15
2	1	PH12-13
3	1	PH12-13
4	1	PH12-15
5	1	PH12-14
6	1	PH12-14
7	1	PH12-14
8	1	PH12-12
9	1	PH12-15
10	1	PH12-15
11	1	PH12-13
12	1	PH12-15
13	1	PH12-12
14	1	PH12-14
15	1	PH12-12
16	1	PH12-15
17	1	PH12-14
18	1	PH12-12
19	1	PH12-13
20	1	PH12-12

Part B

Question	Marks	Outcome
21 (a)	4	PH12-12
21 (b)	4	PH12-12
21 (c)	3	PH12-12
22	4	PH12-12
23	2	PH12-12
24	3	PH12-12

Question	Marks	Content
25	3	PH12-13
26	3	PH12-13
27 (a)	3	PH12-13
27 (b)	3	PH12-13
28 (a)	4	PH12-13
28 (b)	4	PH12-13
29	3	PH12-14
30 (a)	3	PH12-14
30 (b)	2	PH12-14
30 (c)	4	PH12-14
32	3	PH12-14
33	4	PH12-15
34	3	PH12-15
35	6	PH12-15
36	6	PH12-15