Student Number

2021

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

PEM

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen Black pen is preferred
- Draw diagrams using pencil
- Approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your student number in the space provided

Total marks – 100

100 marks
This exam has two parts, Part A and Part B

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

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

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

Use the multiple choice answer sheet for Questions 1-20

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1 What is the S.I. unit for gravitational field strength.

(A) $m\ s^{-2}$

(B) J

(C) N

(D) kg

2 Which of the following equations would determine the current flowing in two identical parallel current carrying conductors?

(A) $\frac{F}{lB}$

(B) $\sqrt{\frac{F2\pi r}{l\mu_0}}$

(C) $\frac{F}{\mu_0 2\pi r^2}$

(D) $\frac{Fr2\pi}{I_2\mu_0}$

3 A charged particle in a conductor experiences a force when moving through a magnetic field. The right-hand palm rule can be used to determine the direction in which the particle moves. What principle explains the direction in which it flows.

(A) Motor effect

(B) Faradays law

(C) Lenz's law

(D) Back EMF

4 In the 1940's Louis Essen & A C Gordon Smith measured the speed of light by producing standing waves with microwaves of known frequencies inside resonance cavities.

What further measurement would be required to determine the speed of light?

(A) The oscillation rate of the circuit that produced the wave

(B) The amplitude of the wave

(C) The period of the wave

(D) The length of the cavity

5 Which of the following was not a major contribution of James Clerk Maxwell?

(A) Proved that EMR exists beyond the visible spectrum.

(B) Unified the fields of Electricity, magnetism and light.

(C) Calculated the speed of light.

(D) Explained how EMR propagates.

6 A Beta minus b- decay usually occurs under what conditions?

(A) When a nucleus has too many neutrons.

(B) When a nucleus is unstable.

(C) Extreme heat and gravitational pressure.

(D) When a nucleus has too many protons

7 The electron-volt is used because:

(A) it is a convenient unit for quantities of energy that are extremely small

(B) it can quantify the potential difference between electrons

(C) It can accurately determine the amount of electrons in 1 V

(D) It allows large values to simplified

8 Which of the following is not a fundamental particle of the standard model of matter?

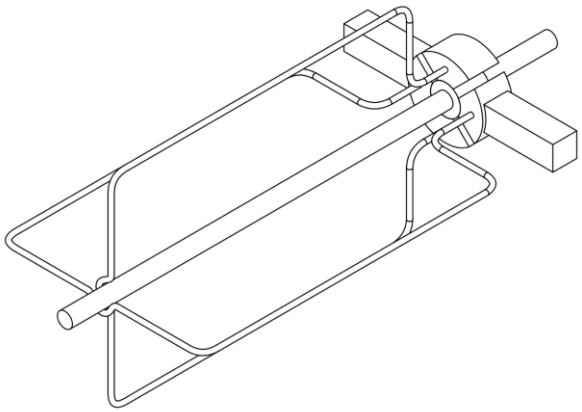
(A) Electron

(B) Muon

(C) Meson

(D) Strange

9 A generator shown below is made with multiple coils set at regular angles on the armature.



The desired result of this modification would be:

(A) A smoother output of voltage

(B) A more efficient generator

(C) Larger power output

(D) Multi-phase AC power output

10 A light bulb produces unpolarised light and has an intensity of 120 lumens at 0.5 m. Determine the intensity of the light from the bulb after it has passed through a polarising filter that is placed 3.0 m from the bulb.

(A) 6.9 lumens

(B) 12 lumens

(C) 1.7 lumens

(D) 3.3 lumens

11 A dog is tethered to the ground on a 2.0 m leash. With the leash pulled taught, the dog runs around in circles chasing its tail. The dog runs 8.0 m along its circular path in 2.0 s. Calculate its angular velocity.

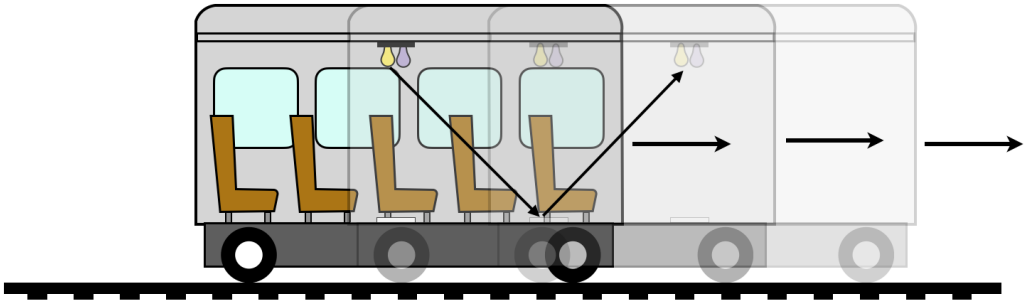
(A) 1.0 rad s^{-1}

(B) 2.0 rad s^{-1}

(C) 3.5 rad s^{-1}

(D) 4.0 rad s^{-1}

12 Einstein proposed a thought experiment in which a light emitting device was used on a moving train. An illustration of part of this experiment is shown below.



This thought experiment was used to demonstrate which feature of special relativity:

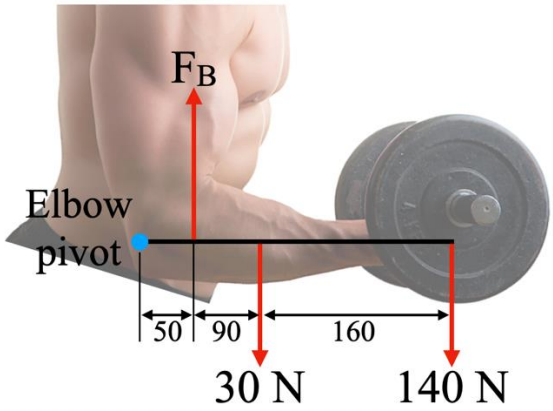
(A) Length contraction

(B) Time dilation

(C) Mass dilation

(D) Energy / mass equivalency

13 A man is holding a weight of 140 N as shown below. The 30 N force is the weight of the forearm acting at its centre of mass.



Determine the force required by the bicep to the hold the weight at the height shown.

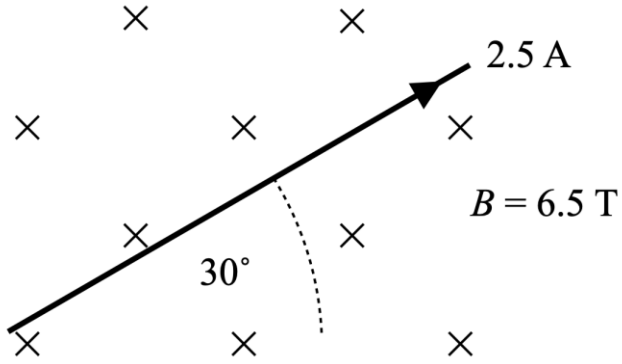
(A) 502 N

(B) 754 N

(C) 784 N

(D) 924 N

14 Calculate the force acting on the current carrying conductor shown below.



(A) 6.2 N m^{-1}

(B) 8.1 N m^{-1}

(C) 14 N m^{-1}

(D) 16 N m^{-1}

15 Two moons of Jupiter, Io and Europa, have respective orbital periods of 1.77 days and 3.55 days. Calculate the orbital radius of Io if Europa has an orbital radius of 671 000 km.

(A) 334 555 km

(B) 421 909 km

(C) 643 618 km

(D) 751 030 km

16 A newly produced radioactive medical isotope takes 16 hrs to reach the hospital. What percentage of the isotope has decayed by the time it reaches the medical technicians if the isotope has a half-life of 2.2 days.

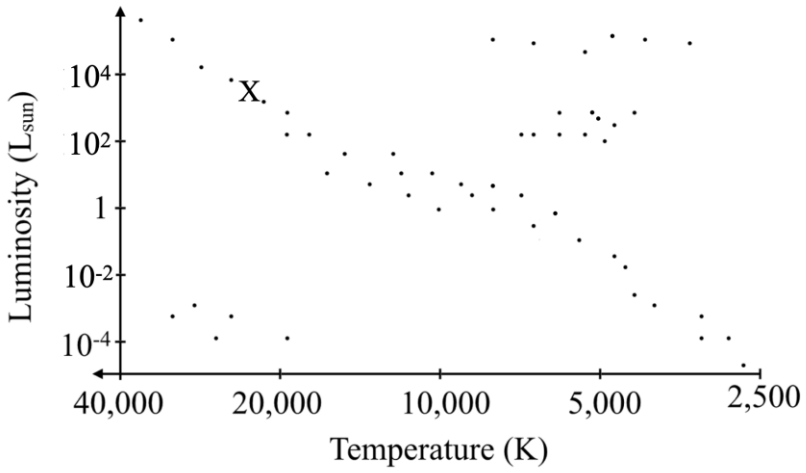
(A) 7 %

(B) 13 %

(C) 15 %

(D) 19 %

17 The following HR diagram has a star indicated with an X



What is the most likely dominant nucleosynthesis reactions occurring in the core of star X.

(A) Proton-proton with a small amount of CNO

(B) CNO and a small amount of Proton-proton

(C) Proton-proton with a small amount of Triple Alpha

(D) CNO with a small amount of Triple Alpha

18 Calculate the escape velocity of an 80 kg object on the surface of the Earth.

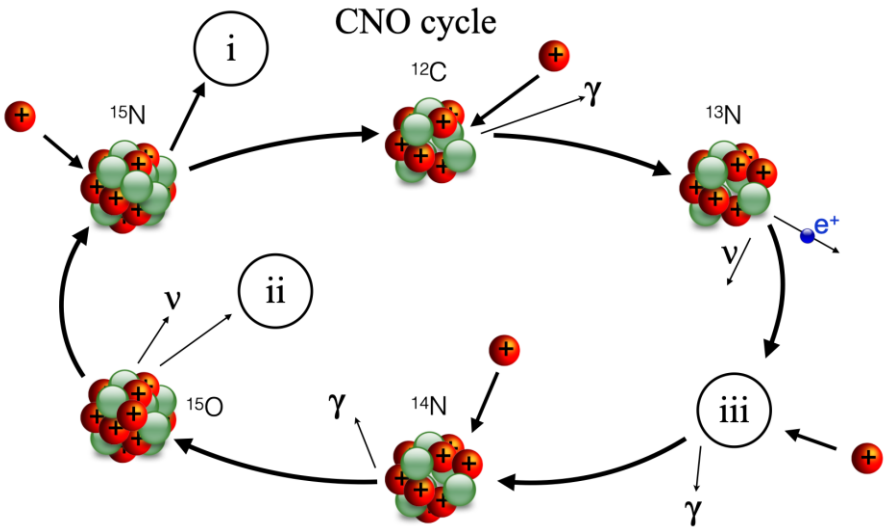
(A) 11209 m s^{-1}

(B) 7926 m s^{-1}

(C) 13478 m s^{-1}

(D) 10112 m s^{-1}

19 The diagram below shows an incomplete CNO cycle

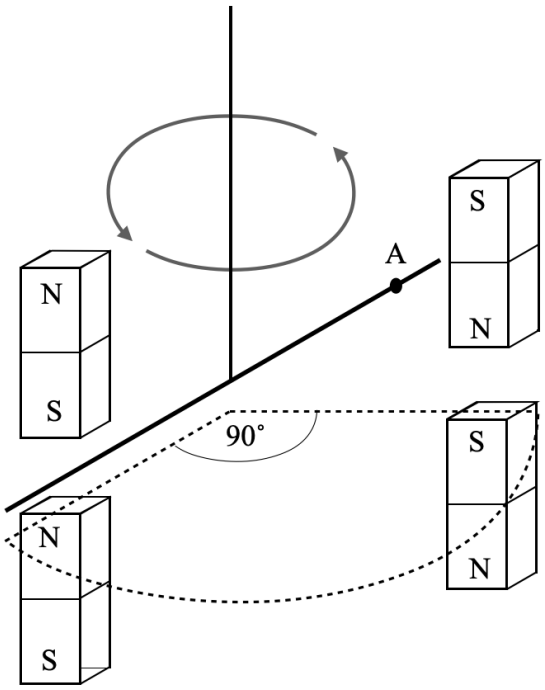


Which of the following correctly identifies the particles labelled i, ii, and iii?

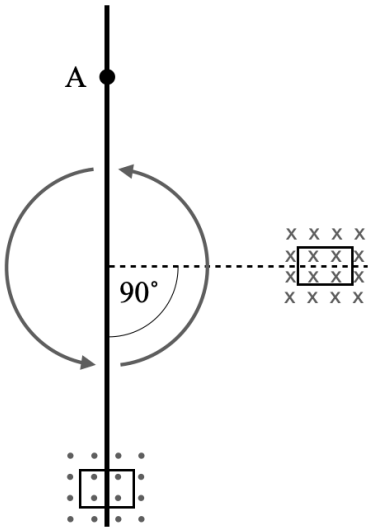
	i	ii	iii
(A)	^{1}H	γ	^{15}N
(B)	γ	^{1}H	^{15}C
(C)	^{4}He	e^{+}	^{13}C
(D)	e^{+}	e^{+}	^{13}N

20 A conductor is suspended by a string so that it can rotate between two sets of magnets as shown in the image below. The magnets are placed at 0˚ and 90˚ in the rotation.

Side view

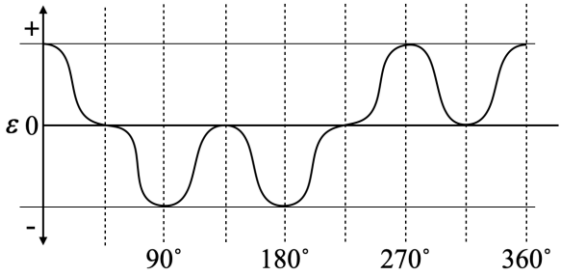


Top view

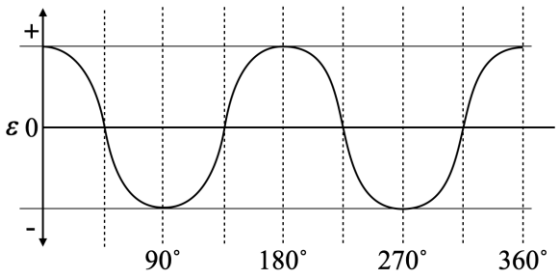


A multi-meter is attached at point A to measure the EMF in the coil. Which of the following graphs correctly shows the EMF in the conductor during the rotation?

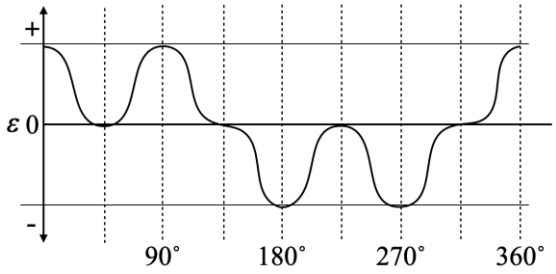
(A)



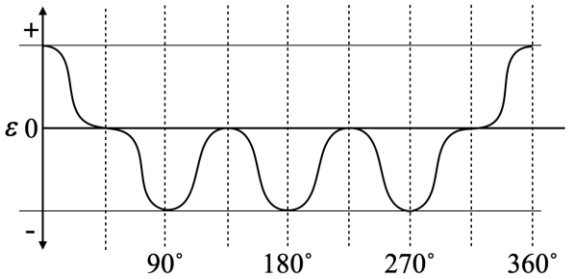
(C)



(B)



(D)



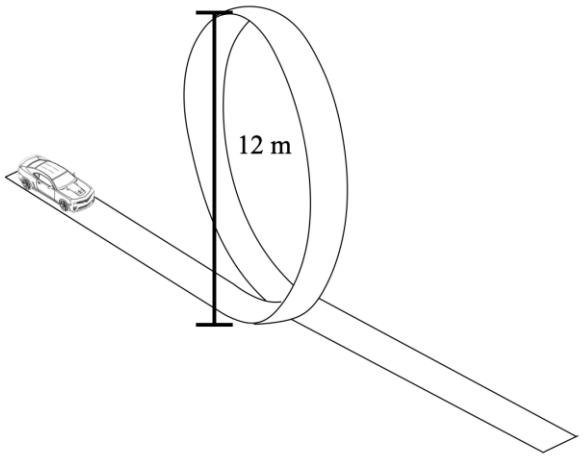
Part B – 80 marks
Attempt questions 21-36
Allow about 2 hour and 25 minutes for this part

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 (3 marks)

A 1100 kg car with an 85 kg driver are attempting a loop de loop at a stunt car rally. If the diameter of the loop is 12 m as shown in the diagram, what speed must the car travel so that the driver feels a normal force, at the peak of the loop, equivalent to his weight force.



Question 22 (9 marks)

(a) A student performed a depth study to assess the accuracy of a projectile launcher. **3**

The student measured the projectiles launched to have an average initial velocity of 6.5 m s^{-1}.

Calculate the maximum horizontal distance the projectile would reach if launched from a height of 1.1 m and landing on the floor.

(b) The student's results for the projectile launched at an angle of 45˚ are shown below.

Launch angle (˚)	Horizontal Displacement (m)		
	Trial 1	Trial 2	Trial 3
45	5.18	5.11	5.37

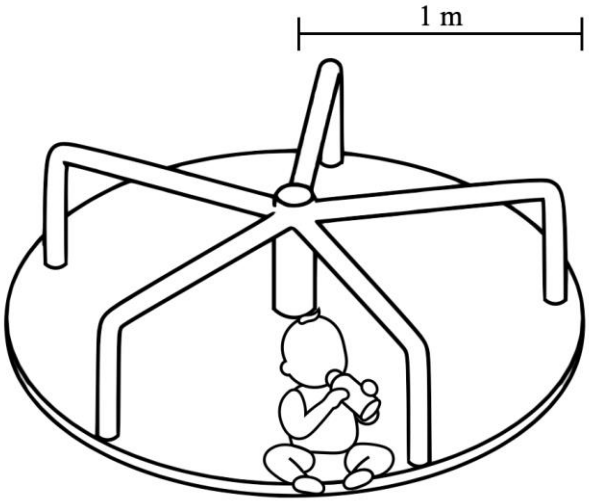
(i) Assess the accuracy of the given results. **2**

(ii) Assess the reliability of the given results. **2**

(iii) Suggest plausible explanations for the evident accuracy and reliability **2**

Question 23 (4 marks)

A baby is sitting on the edge of a playground merry-go-round as shown below. The merry go round has a radius of 1 m.



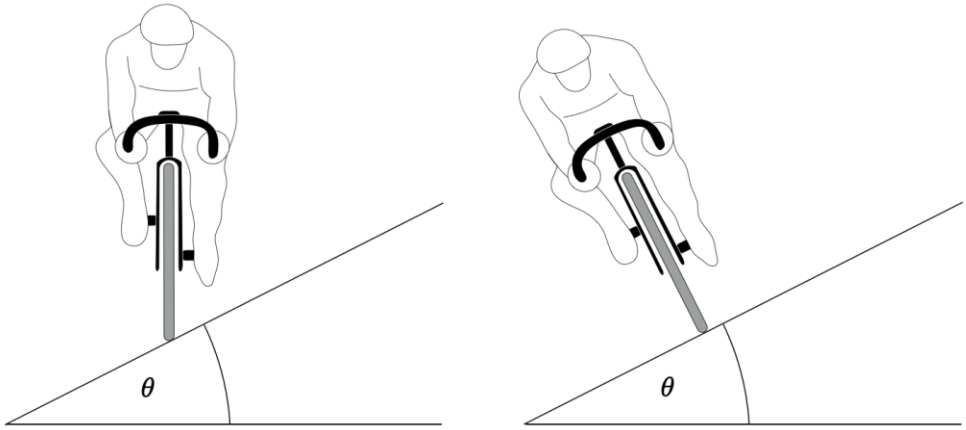
A toddler comes over and begins to run around the merry-go-round whilst spinning it. The toddler quickly reaches his maximum running speed, completing one rotation every 4 s. Assuming the baby does not hold onto the railing, what is the least coefficient of static friction between the baby and the merry-go-round that will allow the baby to stay in place, without sliding.

Question 24 (4 marks)

A velodrome is an arena for track cycling that features steeply banked oval tracks.

A rider who has just entered the velodrome rides with their bike and posture almost vertical. However, after they have increased their speed the bike and posture become perpendicular to the track.

The two positions are shown below.



Explain why both positions are necessary.

Question 25 (4 marks)

Compare Back emf to the current produced in a generator.

Question 26 (4 marks)

Describe how a transformer works and explain how the iron core increases efficiency.

Question 27 (3 marks)

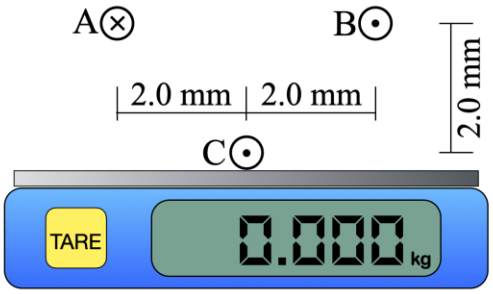
Using Newton's laws of motion, explain why electric motors have maximum operating speeds.

Question 28 (4 marks)

A transformer is supplied with 20 000 V and 100 A. The voltage output of the transformer is 12 400 V. If the transformer has an efficiency of 90%, determine the output current.

Question 29 (5 marks)

Three conductors are set up so that their cross sections are shown below. Conductor A and B are fixed, and conductor C is fixed to the surface of a tarred scales. All three conductors run parallel to each other for 10 cm.



A current of 120 A is run through conductor A into the page whilst a current of 80 A is run through conductor B and C out of the page.

Determine the reading on the scale.

Question 30 (4 marks)

Explain how a star's translational velocity can be deduced.

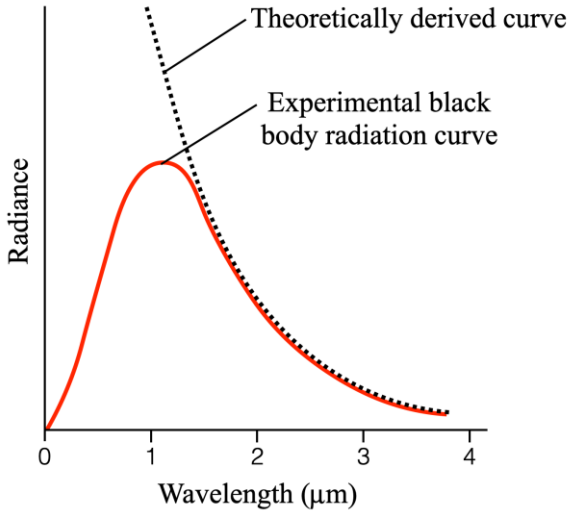
Question 31 (5 marks)

Describe how a star's absorption spectra is produced in the laboratory and explain the observed results.

Question 32 (5 marks)

How was Planck able to account for the shape of the graph below and describe why this was not an accepted explanation.

Radiance of radiation from a black body



Question 33 (6 marks)

How did Einstein's model of light account for the observed results of the photoelectric effect?

Question 34 (9 marks)

Discuss how historical experiments that probed the atom were made possible by known scientific principles and ideas.

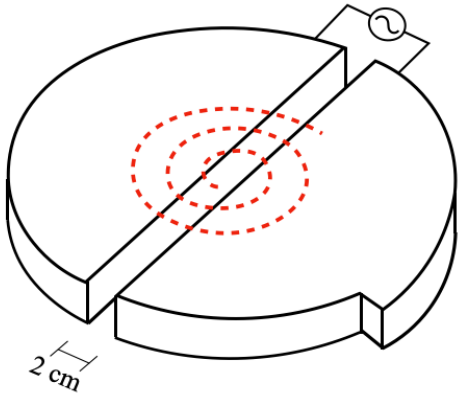
Question 35 (5 marks)

(a) Explain the origins of the Sun's energy and how it is able to travel the vast distance between the Sun and the Earth. **3**

(b) Account for the suns production of a full range of EMR. **2**

Question 36 (6 marks)

(a) A cyclotron is a particle accelerator with two D shaped chambers as shown below. **4**



The D shaped chambers are supplied with a high frequency alternating current with each chamber supplied an opposite charge. A 7.0 x 10^{-4} T magnetic field is produced through the chambers so that the field is perpendicular to the path of the protons causing them to undergo circular motion whilst in the chamber. A proton on a spiralling path enters a chamber at 33 500 m s^{-1}. It re-enters the same chamber 1.0 cm from its last entry point. Calculate the voltage between the chambers if they are separated by 2.0 cm.

(b) Describe the evidence that could be collected from a particle accelerator that can confirm elements of the standard model of matter. **2**

END OF EXAM

PEM

2021 Trial HSC Physics Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21

Criteria	Marks
Correctly calculates required speed	3
Substitutes correctly including correct masses	2
Attempts to equate centripetal force to sum of gravitational force and normal force	1

Sample answer:

$F_c = F_g + F_W$

$\frac{mv^2}{r} = F_g + F_W$

$v = \sqrt{\frac{(F_g + F_W)r}{m}}$

$v = \sqrt{\frac{(1100+85)g+85g)6}{1100+85}}$

$v = 7.9 \text{ m s}^{-1}$

Question 22 (a)

Criteria	Marks
Calculates correct range of projectile	3
Calculates total time of flight (1.26 s)	2
Calculates correct time at max height with working (0.47 s)	1

Sample answer:

$v = u + at$

$t = \frac{u-v}{-a}$

$t = \frac{6.5\cos 45 - 0}{9.8}$

$t_{\max height} = 0.47 \text{ s}$

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

$s = 6.5 \sin 45\ (0.47) - \frac{9.8}{2} 0.47^2$

$s_{\max height} = 1.08 \text{ m}$

$t = \sqrt{\frac{2s}{a}}$

$t = \sqrt{\frac{2(-1.08-1.1)}{-9.8}}$

$t_{from \max height} = 0.67 \text{ s}$

$t_{total} = t_{\max height} + t_{from \max height}$

$t_{total} = 0.47 + 0.67$

$t_{total} = 1.14 \text{ s}$

$\Delta x = u_x t$

$\Delta x = 6.5 \cos 45\ (1.14)$

$\Delta x = 5.2 \text{ m}$

Question 22 (b) i

Criteria	Marks
Makes a judgement of accuracy based on correct reasoning	2
Makes a correct judgement of accuracy	1

Sample answer:

The calculated value for this angle based on the previous question is 5.22 m. The average for the three trials was also 5.22 m. Therefore, the experiment was very accurate when compared with the known value.

Question 22 (b) ii

Criteria	Marks
Makes a judgement of reliability based on correct reasoning	2
Makes a correct judgement of reliability	1

Sample answer:

The experiment had a limited level of reliability. It has a small number of trials which limited its reliability. It had a range of values 0.26 m. This range equated to 5% of the total range which further limited its reliability.

Question 22 (b) iii

Criteria	Marks
Suggests plausible explanations for the accuracy and reliability presented in part i and ii	2
Suggests plausible explanation for the accuracy or reliability presented in part i and ii	1

Sample answer:

The value of initial velocity used was a measured average. It is highly plausible that the projectile launcher did not produce consistent launch velocities. This would produce a low level of reliability in the results.

If the average initial velocity was calculated from many measurements the measured ranges would produce an accurate average range.

Question 23

Criteria	Marks
Calculates correct coefficient of friction	4
Substitutes values correctly into correct equation	3
Calculates velocity of toddler and equates centripetal force to friction force	2
Calculates velocity of toddler or equates centripetal force to friction force	1

Sample answer:

$v = \frac{s}{t}$

$v = \frac{2\pi r}{t}$

$v = \frac{2\pi 1}{4}$

$v = 1.57 \text{ m s}^{-1}$

$F_c = f$

$\frac{mv^2}{r} = F_N \mu$

$\mu = \frac{v^2}{g}$

$\mu = \frac{1.57^2}{9.8}$

$\mu = 0.25$

Question 24

Criteria	Marks
Explains the necessity of both positions in terms of net forces and bike stability	4
Explains the necessity of both positions in terms of net forces	3
Explains the necessity of one position in terms of net forces and bike stability	2
Explains the necessity of one position in terms of net forces	1

Sample answer:

Stability on a bicycle is achieved when the net torque applied to the bicycle is equal to zero. The lever arm can be considered as the length between the point of contact with the road and the centre of mass. When riding on a flat surface, stability is achieved when the rider and bicycles centre of mass is directly above the point of contact with the road.

In the first position when the rider has a low velocity his centre of gravity is directly over the point of contact. Therefore, gravity does not contribute any torque to the bicycle. At the point of contact the component of the normal force acting on the bike that is perpendicular (clockwise) is equal to the component of the friction force acting on the bike that is perpendicular (counter-clockwise). The two forces create a net torque around the centre of mass equal to zero. The bike is therefore stable in this position.

When an object travelling on a banked track reaches the design speed the friction force is no longer necessary to keep the object on the banked track. We can assume that the rider in the second position is at or close to the design speed. In the second position when the rider has a high velocity his centre of gravity is not over the point of contact. His weight force will then cause a torque at the point of contact (counter-clockwise). Because friction is not needed at high velocities on a banked track this torque is necessary to balance the torque around the centre of mass created by the component of the normal force acting on the bike that is perpendicular (clockwise).

Question 25

Criteria	Marks
Compares in detail the mechanical production, scientific principles, and direct use of back EMF and generated current	4
Compares the mechanical production, scientific principles, and direct use of back EMF and generated current	3
Compares two of the following • mechanical production • scientific principles • direct use	2
Compares one of the following • mechanical production • scientific principles • direct use	1

Sample answer:

Property	Back EMF	Generated Current
Mechanical production	• A coil on an armature is given a external voltage. The current flowing through the coil produces a magnetic field. • The coil is surrounded by a magnetic field produced by magnets. • The supplied and generated fields interact to create a net torque acting on the armature. • As the coil rotates about the central axis a back EMF is induced as the coil move through a magnetic field.	• An external mechanical torque is applied to the armature of the generator in order to create a rotation. • The armature has coil of conducting wire around it. • The coil is surrounded by a magnetic field produced by magnets. • As the coil rotates about the central axis an induced current is produced in the coil as it moves through the magnetic field.
Scientific Principles of production	Conductor moving through a magnetic field causes an induced current to flow following faradays law. The direction of the current will flow in such a way as to produce a magnetic field that opposes the change in flux according to lenz's law.	Same as Back EMF
Direct use	No direct use besides reducing current drawn by motor	Can be used by other devices requiring electricity

Question 26

Criteria	Marks
Explains how the iron core increases efficiency and accurately describes how a transformer works.	4
Explains how the iron core increases efficiency and describes how a transformer works.	2-3
Identifies a contribution of the iron core or identifies the use of a transformer.	1

Sample answer:

A transformer is an electrical device that takes the voltage of one circuit and induces a different voltage in another circuit. Faradays law states that a changing magnetic flux through a conductor will cause an induced EMF. The changing flux originates with the alternating current supplied by the primary coil. The changing magnetic flux is directed to the secondary coil where it will induce an EMF in that coil. The ratio of turns in each coil determines change in voltage.

Efficiency in a transformer is determined by the amount of flux linkage. Flux linkage is the how much flux from one coil passes through the other coil. The iron core increases the flux linkage by firstly increasing the strength of the induced magnetic fields. The iron core also increases the flux linkage by directing the flux lines, so flux linkage is maximised.

Question 26

Criteria	Marks
Demonstrates a sound understanding of the physics principles involved in a motor and a generator AND considers the energy changes and relates these to the motion of the vehicle both in propulsion and in braking AND clearly explains the physics principles involved in the propelling and braking of the vehicle	4
Demonstrates an understanding of the physics principles involved in a motor and a generator AND describes relevant energy changes	3
Demonstrates an understanding of the physics principles involved in a motor or generator OR shows some understanding of how a motor can act as a generator	2
Identifies some relevant information	1

Sample answer:

When acting as a motor, the vehicle converts electrical energy to kinetic energy due to the motor effect, thus propelling the vehicle. A motor consists of a rotating coil in a magnetic field.

When power is cut, the rotating coil in the magnetic field induces an emf to due to a change in magnetic flux. This allows the motor to act as a generator, which has essentially the same parts as a motor. When it acts as a generator, kinetic energy is converted to electrical energy, and so by Lenz's law, the motion of the rotor is opposed. This acts to slow the vehicle.

Question 27

Criteria	Marks
Use at least two correct Laws of motion to explain maximum operating speeds of electric motors.	3
Attempts to substitute into correct formulae to determine the upward force required on wire 2 AND/OR the current through wire	1-2

Sample answer:

When a current is supplied to the coil of an electric motor an induced magnetic field is produced. The magnetic fields interact with the supplied magnetic field to create a force acting on the coil which is allowed to rotate. Newtons second law states that a net extremal force applied to a mass will cause it to accelerate. As such the coil will begin to rotate about its central axis.

As the coil accelerates a back EMF is induced in the coil which flows in the opposite direction of the supplied EMF. The coil will keep accelerating until the back EMF grows till it is the same value as the supplied EMF. At this point the net force acting on the motor is zero (assuming the friction force is negligible) and the motor will have reached its maximum operating speed.

The motor will continue without a net force because according to Newtons first law of motion, object sin motion will remain in motion.

Question 28

Criteria	Marks
Correctly calculates correct current	4
Applies efficiency correctly with incorrect current or calculates correct current without efficiency	3
Substitutes values correctly	2
Identifies correct formula	1

Sample answer:

$\eta = \frac{P_o}{P_i}$

$\eta = \frac{V_s I_s}{V_p I_p}$

$I_s = \frac{\eta \times V_p I_p}{V_s}$

$I_s = \frac{0.9 \times 20000 \times 100}{12400}$

$I_s = 145.2 \text{ A}$

Question 29

Criteria	Marks
Correctly calculates the value on the scales in kg.	5
Calculates the y components of the two forces	4
Calculates correctly the forces applied by A and B	3
Identifies correct formula and correctly substitutes correct values into formula	2
Correctly calculates distance between wires	1

Sample answer:

$F_{ACy} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r} l \sin\theta$

$F_{ACy} = 2 \times 10^{-7} \times \frac{120 \times 80}{0.003} \times 0.1 \sin 45$

$F_{ACy} = 0.048 \text{ N}$

$F_{BCy} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r} l \sin\theta$

$F_{BCy} = 2 \times 10^{-7} \times \frac{80 \times 80}{0.003} \times 0.1 \sin 45$

$F_{BCy} = 0.032 \text{ N}$

$F_c = 0.048 - 0.032$

$F_c = 0.016 \text{ N}$

Therefore, the reading on the scales would be 0.002 kg

Question 30

Criteria	Marks
Describes how translational velocity is deduced, explains how radial velocity is calculated and identifies how tangential velocity is measured.	
Answer that includes: • Description of how translational velocity is deduced • Description of how radial velocity is calculated • Identification of how tangential velocity is measured.	
Answer that includes two of the above	2
Answer that includes one of the above	1

Sample answer:

Due to the doppler effect if a star is moving towards the Earth its observed wavelengths shorten and are blue-shifted. Stars moving away from the Earth are red-shifted. The extent of shifting reveals how fast the star is moving. In this way the Radial velocity of a star can be measured.

The tangential velocity can be calculated using the measured angular velocity and measured distance. The star's distance is measure by trigonometric parallax or the inverse square law method.

The actual translational velocity of the star is the vector sum of the radial velocity and the tangential velocity

Question 31

Criteria	Marks
Describes how a spectroscope produces a spectrum and explains the visible and non-visible bands.	5
Describes how a spectroscope produces a spectrum and explains the visible or non-visible bands.	4
Describes how a spectroscope produces a spectrum and describes the visible and non-visible bands	3
Describes how a spectroscope produces a spectrum or explains the visible or non-visible bands.	2
Identifies a spectroscope producing a spectrum or describes the visible and non-visible bands.	1

Sample answer:

Light from a star, as viewed through a telescope is passed through a spectroscope. The spectroscope passes the light through a diffraction grating that splits the light into its different wavelengths. The produced spectrum can either be observed with the naked eye or detected with a digital photoreceptor. The absorbed bands of the spectrum will appear as thin dark bands.

The visible component of the spectrum constitutes the full range of wavelengths that were not absorbed by the star’s atmosphere. The dark lines of the absorption spectrum correspond to the wavelengths that were absorbed. Atoms in the gas absorb photons of wavelength corresponding to the quanta of energy involved in possible transitions of electrons to higher energy levels.

Question 32

Criteria	Marks
A coherent and well structured response that includes: • Quotations of energy according to E=hf • An explanation for the 'missing energy' • An account for the accumulation of 'missing energy' related to graph • An identification of the reasons for why it was not accepted at the time	5
A response that includes: • Quotations of energy according to E=hf • an explanation for the 'missing energy' • an account for the accumulation of 'missing energy' related to graph • an identification of the reasons for why it was not accepted at the time	4
A response that includes three of the above	3
A response that includes two of the above	2
A response that includes one of the above	1

Sample answer:

The reason why the experimental peak intensity does not hit the theoretical curve is due to the quantisation of the energy. Plank mathematically described this quantisation as e=nhf, where n was an integer number. Because the energy is quantised there are certain energy levels that are not emitted. The non-emitted energy accumulates as 'missing' energy more noticeably for hotter objects with more energy levels. Therefore, the measured peak intensity drops away from the theoretical curve as the objects get hotter, which on the curve occurs in the UV range.

Plank provided no substantial explanation as to why the energy was quantised or what accounted for the integer value. This theory also did not comply with classical physics and was therefore not an acceptable explanation.

Question 33

Criteria	Marks
Accounts for three photoelectric effects using Einstein's model	3
Accounts for two photoelectric effects using Einstein's model	2
Accounts for one photoelectric effects using Einstein's model	1

Sample answer:

Einstein's model of light described light behaving like particles called photos, each careening a discrete package of energy. The amount of energy of each photon was determined by planks E=hf relationship. The collisions between photons and electrons leads to the photoelectric effect.

It was observed that the photoelectric effect only occurred above specific frequency of EMR for each metal. Einstein accounted for this by considering the amount of energy required to eject a photoelectron from the metal, which he called the work function. If the photon had an energy level equal to or above the work function the photoelectron would be ejected. If it was below the work function the energy would be re-emitted by the electron and not ejected. The amount of energy was determined by the frequency.

Similarly, it was observed that the photoelectric effect was instantaneous. Because a photon immediately transferred all or none of its energy, the photoelectric effect was instantaneous. There was no need for an energy building delay which a classical physics approach would suggest.

It was further observed that increasing the intensity of light increased the photocurrent up to a maximum value. Einstein's model described intensity as the amount of photons. An increase in light intensity was synonymous with an increase in the amount of photons. By increasing the number of photons, logically more photons would be available to cause the photoelectric effect with surface electrons. A maximum photocurrent occurs because there is only a finite amount of electrons on a metals surface to be ejected.

Question 34

Criteria	Marks
Describes the experiment and explains the necessity of scientific principles or ideas for three historical experiments that probed the atom.	5-6
Describes the experiment and explains the necessity of scientific principles or ideas for two historical experiments that probed the atom.	3-4
Describes the experiment and explains the necessity of scientific principles or ideas for one historical experiment that probed the atom.	1-2

Sample answer:

J.J. Thompson conducted an experiment to measure the charge to mass ratio of an electron using the ideas developed by Faraday and Lorentz. He passed a cathode ray through an electric field and a magnetic field that were perpendicular to each other. The two fields in this arrangement caused deflection of the ray in opposite directions. By adjusting the strength of the two fields the forces acting on the ray were brought into equilibrium and the ray was not deflected. Thompson was able to then equate the known scientific principles of electric field strength and the force on a moving charged particle in a magnetic field. By further introducing the principle of centripetal force he was able to derive a value for the charge to mass ratio and definitively confirm the particulate nature of cathode rays.

Robert Millikan used the known scientific principles of Lorentz and Newton to calculate the charge of an electron. He introduced oil drops between two charged metal plates. Using the known oil density, mass of the droplets was determined from their observed radii. Charged drops became suspended between plates when the force of gravity was equal to the electric force between the plates. By equating the known force of an electric field developed by Lorentz, and the force of gravity developed by Newton, Millikan was able to produce an expression for the charge of the drops. The charge on a drop was always a multiple of 1.6×10^{-19} C.

James Chadwick conducted an experiment to reveal the properties of neutrons based on work developed by Curie, Bothe and Becker, and the Joliots. Chadwick bombarded Beryllium with alpha particles to cause unstable nuclei to emit radiation (neutrons). The radiation passed through Hydrogen rich paraffin, ejecting protons. The protons kinetic energy was measured. Using the scientific principle of the law of conservation of momentum Chadwick deduced that the radiation was particles with no charge and a similar mass to protons.

Question 35 (a)

Criteria	Marks
Explains the sun's energy origins in terms of gravity and mass defect and describes the self-propagating nature of EMR.	3
Describes the sun's energy origins in terms of gravity or mass defect and describes the self-propagating nature of EMR.	2
Describes the sun's energy origins in terms of gravity or mass defect Or Describes the self-propagating nature of EMR.	1

Sample answer:

Stars are driven by gravity. Gravitational potential energy is converted into kinetic energy. As the density increases more and more collisions occur causing kinetic energy to be converted into thermal energy and the mass increases in temperature. With large enough temperatures and pressure, two protons can be forced close together enough that the strong nuclear force will hold them together against their mutual electrostatic repulsion. In doing so a large amount of energy is released. The released energy is a result of a mass defect between the reactants and products of the fusion reactions. $E=mc^2$ relates the amount of mass to the amount of energy.

The energy released during a fusion reaction is EMR. When an electromagnetic wave is produced an electric field produces a perpendicular magnetic field. The magnetic field then produces a perpendicular electric field. This process continues infinitely in a vacuum. In this way EMR is self-propagating and does not require a medium to travel the vast distances in space.

Question 35 (b)

Criteria	Marks
Describes the loss of energy as photons travel through the sun and relates the resulting energies to the spectrum of EMR	2
Describes the loss of energy as photons travel through the sun	1

Sample answer:

The suns fusion reactions occur in its core. The primary source of energy released is gamma rays. A single photon can take up to 100 000 years to reach the surface of the sun. During this time it the photons are constantly absorbed, scattered and re-emitted as it passes through the matter inside the sun. Conservation of energy principles dictate that the photons will have lost energy during these many collisions leading to photons at the surface with varying energies. All these energies sum up to give the resulting full range of EMR.

Question 36 (a)

Criteria	Marks
Calculates correct voltage showing full working	4
Equates Work to a change in kinetic energy and calculates a value for the radius and velocity	3
Calculates a second velocity using a calculated radius	2
Calculates the correct radius of the first path	1

Sample answer:

$qvB = \frac{mv_1{}^2}{r_1}$

$r_1 = \frac{mv_1}{qB}$

$r_1 = \frac{33500 \times m}{7 \times 10^{-4} \times q}$

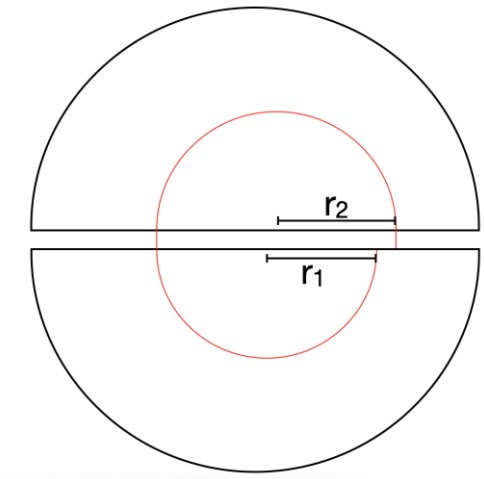
$r_1 = 0.5$ m

$qvB = \frac{mv_2{}^2}{(r_1 + 0.005)}$

$v_2 = \frac{qB(r_1 + 0.005)}{m}$

$v_2 = \frac{q \times 7 \times 10^{-4}(0.5 + 0.005)}{m}$

$v_2 = 33\,835$ m s^{-1}



$W = qV = \Delta E_k$

$qV = E_{k2} - E_{k1}$

$V = \frac{E_{k2} - E_{k1}}{q}$

$V = \frac{0.5mv_2{}^2 - 0.5mv_1{}^2}{q}$

$V = 0.12$ V

Question 36 (b)

Criteria	Marks
Describes the evidence that can be collected from a particle accelerator	2
Identifies the evidence that can be collected from a particle accelerator	1

Sample answer:

Particle accelerators can measure the velocity, mass and charge of particles to determine its identity. Tracking devices can reveal a particles curvature of path in an electric field and magnetic field, to determine electric charge and momentum respectively. Using the velocity determined from a particle-identification detector, the mass can be determined from the momentum. Calorimeters can stop, absorb and measure a particles energy.

Physics

2021 Trial HSC Examination Mapping Grid

Part A

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

Part B

Question	Marks	Outcome
21	3	PH12-12
22 (a)	3	PH12-12
22 (b)i	2	PH12-12
22 (b)ii	2	PH12-12
22 (b)iii	2	PH12-12
23	4	PH12-12

Question	Marks	Content
24	4	PH12-12
25	4	PH12-13
26	4	PH12-13
27	3	PH12-13
28	4	PH12-13
29	5	PH12-13
30	4	PH12-14
31	5	PH12-14
32	5	PH12-14
33	6	PH12-14
34	9	PH12-15
35 (a)	3	PH12-15
35 (b)	2	PH12-15
36 (a)	4	PH12-15
36 (b)	2	PH12-15