Student Name:………………………..

2019 Higher School Certificate
Trial Examination
Physics

General Instructions

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

Total marks: 100

Section 1 – 20 marks

Attempt Questions 1-20

- Allow about 35 minutes for this part

Section II - 80 marks

- Attempt Questions 21-37
- Allow about 2 hours and 25 minutes for this part
- For all questions involving calculations in this section show relevant working

PHYTR19_EXAM

Section I
20 marks

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

Use the multiple-choice answer sheet provided for Questions 1-20

1 In one second the Sun generates 3.8×10^{26} Joules.
About how much mass does the Sun lose to do this?

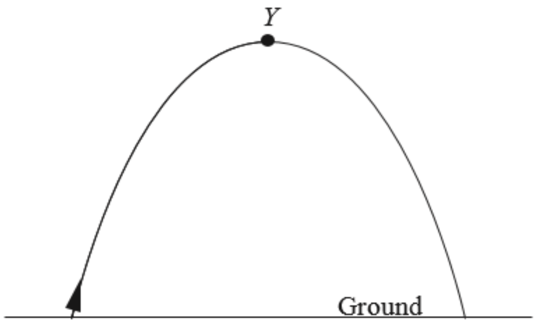
(A) 1 billion tonnes per second.

(B) 700 million tonnes per second.

(C) 6.81 million tonnes per second.

(D) 4.22 million tonnes per second

2 Consider an object undergoing projectile motion under an acceleration of gravity as shown in the figure below.



Choose the most correct statement.

(A) The instantaneous velocity at point Y will be zero.

(B) The vertical component of the velocity is a constant.

(C) The instantaneous vertical velocity will be the same at launch as at landing at impact.

(D) The initial horizontal velocity on launch will be the same as the final horizontal velocity.

3 Shrödinger's model of the atom differed from Bohr's model of the atom by:

(A) allowing for the existence of subshells.

(B) assuming electrons have a constant speed and constant acceleration.

(C) explaining the spectrum of the visible lines in the hydrogen spectrum.

(D) making firm predictions as to the location of the electron around the nucleus.

4 An object travels in a circular path of radius r at a constant speed v. What happens to the object's acceleration if the speed is doubled and the radius stays unchanged?

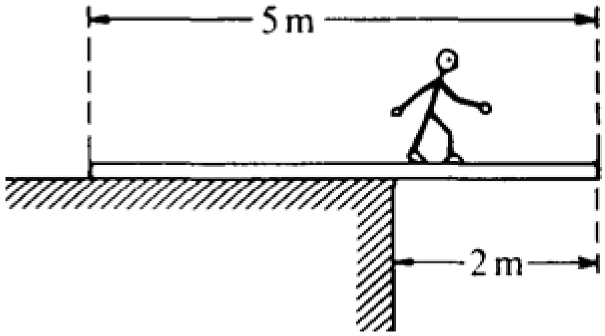
(A) Acceleration remains the same.

(B) Acceleration is halved.

(C) Acceleration is doubled.

(D) Acceleration increases by four times.

5 A 5 metre uniform plank of mass 200 kilograms rests on the top of a building with 2 metres extended over the edge as shown in the figure. How far can a 50 kilogram person venture past the edge of the building on the plank before the plank just begins to tip?



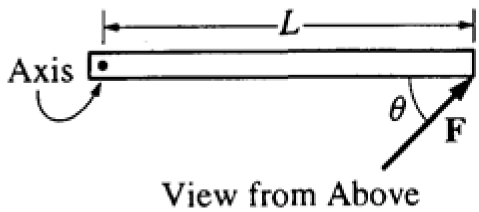
(A) 2 m

(B) 1 m

(C) 0.8 m

(D) 1.5 m

6 A rod on a horizontal tabletop is pivoted at one end and is free to rotate without friction about a vertical axis, as shown in the figure. A force F is applied at the other end, at an angle θ to the rod. If F were to be applied perpendicular to the rod, at what distance from the axis should it be applied in order to produce the same torque?



(A) L sin θ

(B) L cos θ

(C) L tan θ

(D) 2 L sin θ

7 If the angular velocity of a second hand of a clock is 0.105 rad s^{-1} and length of hand is 1.8 cm, then speed of tip of the second hand **is:**

(A) 0.189 cm s^{-1}

(B) 1 cm s^{-1}

(C) 0.189 m s^{-1}

(D) 2 m s^{-1}

8 The mass of Titan as estimated from a point on its surface that is 2575 km from Titan's centre where it has gravitational field strength of 1.35 N kg^{-1} is about:

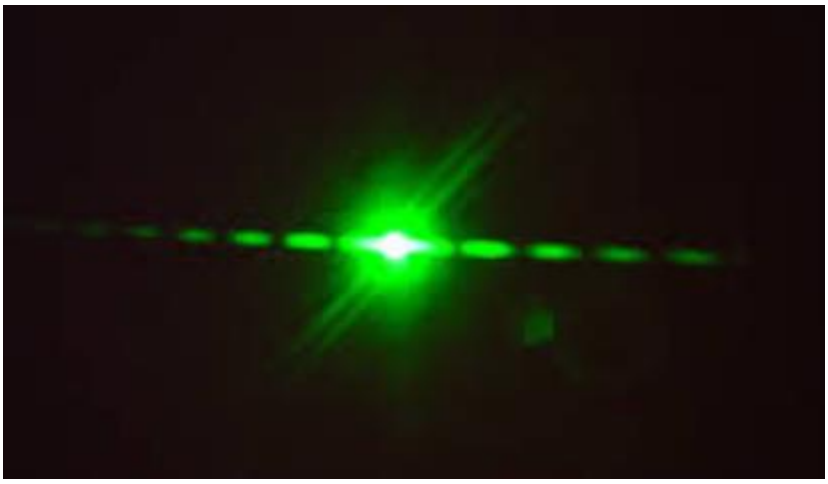
(A) 6.0×10^{23} kg

(B) 1.35×10^{23} kg

(C) 40×10^{9} kg

(D) 9×10^{24} kg

9 A student passed a single beam of laser light through a single narrow slit and got an image on a screen in a darkened room shown below.



What phenomena is responsible for the pattern shown?

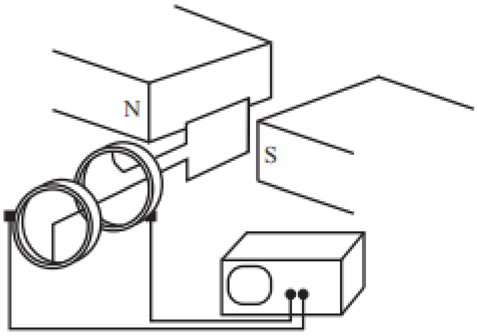
(A) Refraction.

(B) Reflection.

(C) Coherence.

(D) Diffraction.

10 **A** square coil of side length 16 cm has 200 turns and sits within a magnetic field of strength 0.05 T as shown in the figure. A cathode ray oscilloscope is used to measure the emf.



What size emf is produced when it turns at a rate of 46.8 rotation s^{-1}?

(A) 12 V

(B) 24 V

(C) 60V

(D) 0.12 V

11 A positive charged particle q is accelerated in a uniform electric field E starting from rest. If v_0 is the velocity of the particle at the end of distance d, what is the velocity of the particle at distance 2d in the same electric field?

(A) $2 v_0$

(B) $4 v_0$

(C) $8 v_0$

(D) $\sqrt{2} v_0$

12 The gap across a spark plug's electrodes is 0.4 mm. If the voltage between the electrodes is 16000 V what is the electric field in the gap?

(A) 0.64 NC^{-1}

(B) 10 000 000 NC^{-1}

(C) 4 000 000 NC^{-1}

(D) 40 000 000 NC^{-1}

13 The work done to move a charge of 2 μC from a point B to a point A that is at a higher potential is 2.4×10^{-5} J. What is the potential difference between the two points?

(A) 12 V

(B) 1.2 V

(C) 120 V

(D) 1200 V

14 A transformer has 3000 primary turns and 150 secondary turns. It is connected to a 240 V power supply and outputs 15 A. What is the secondary voltage and the primary current?

(A) 18 V, 1 A

(B) 20 V, 1 A

(C) 12 V, 0.75 A

(D) 0.75 V, 12 A

15 Two straight current carrying wires exert a force of F newtons per metre. If the separation distance is doubled the force per length will be:

(A) 2F

(B) F/2

(C) F/4

(D) 4F

16 Millikan's oil drop experiment was important because:

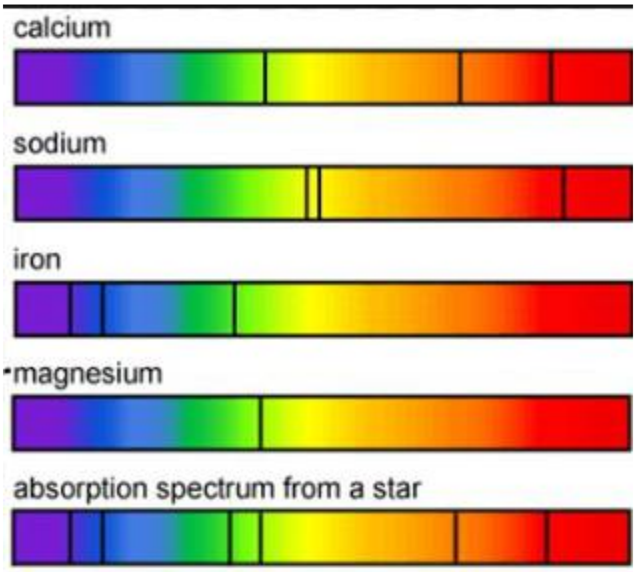
(A) it quantified the charge on an electron.

(B) it established the charge to mass ratio of the electron.

(C) it used a simple apparatus to equate gravity and electrostatic charge.

(D) it enabled the calculation of the mass of an proton when combined with previous data from JJ Thomson.

17 The absorption emission spectral lines for a number of elements are shown in the figure below along with the absorption spectral emission from a star.



The elements the star contains are:

(A) calcium, sodium and iron.

(B) calcium, iron and magnesium.

(C) calcium, sodium and magnesium.

(D) calcium, sodium, iron and magnesium.

18 The photoelectric effect experimental evidence that did **not** support the wave nature of light was:

(A) a heated filament emits electrons in a vacuum.

(B) as the intensity of light increases the number of electrons emitted from the surface increases.

(C) monochromatic light of high intensity doesn’t always cause electron emission from all metals.

(D) the maximum energy of the emitted electrons increases linearly with the frequency of the light but is independent of its intensity.

19 $_{14}C_{6}$ has a half-life of 5730 years how many grams of a 4.0 g sample would be left after 3.5 half-lives?.

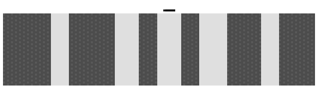
(A) 1 g

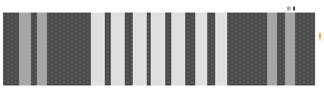
(B) 0.5 g

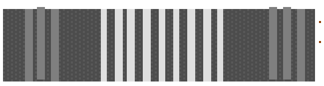
(C) 0.375 g

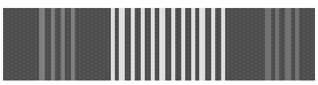
(D) 0.35 g

20 The four images below represent the double slit interference patterns obtained using the same source of monochromatic light. In each case the distance to the screen was the same. Which one represents the smallest slit separation?

(A) 

(B) 

(C) 

(D) 

Section II - 80 marks
Physics

Attempt Questions 21-37
Allow about 2 hours and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Extra writing space is provided on pages 29 and 30. If you use this space, clearly indicate which question you are answering.

Question 21 (3 marks)

Early scientists made exhaustive efforts to accurately measure the speed of light. Explain how it is that now, the speed of light is used to define the measure of distance. **3**

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Question 22 (3 marks)

In an early type of particle accelerator, the nuclei of hydrogen isotopes of deuterium stripped of its electron called deuterons (one proton and one neutron) were made to move in a circular path within a toroidal tube (a hollow ring) of diameter 1 m. **3**
Calculate the magnetic field required to constrain a deuteron ($q_p = +1.602 \times 10^{-19}$ C) within the toroidal tube at a velocity of 9×10^6 m s^{-1}.

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Question 23 (3 marks)

A manufacturer of solar cells wanted to determine the work function of silicon under low levels of artificial light. To test the solar cells, the manufacturer used a light source which emitted photons with a wavelength of 510.6 nm.
Under these conditions the photoelectrons emitted were found to have a maximum kinetic energy of 5.36×10^{-20} J.

(a) Determine the maximum energy in joules of the highest energy incident photons. **2**

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(b) Calculate the work function of the silicon in joules. **1**

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Question 24 (3 marks)

The International Space Station orbits 4.00×10^{2} km above Earth's surface in a circular orbit. Calculate the orbital speed of the International Space Station. **3**

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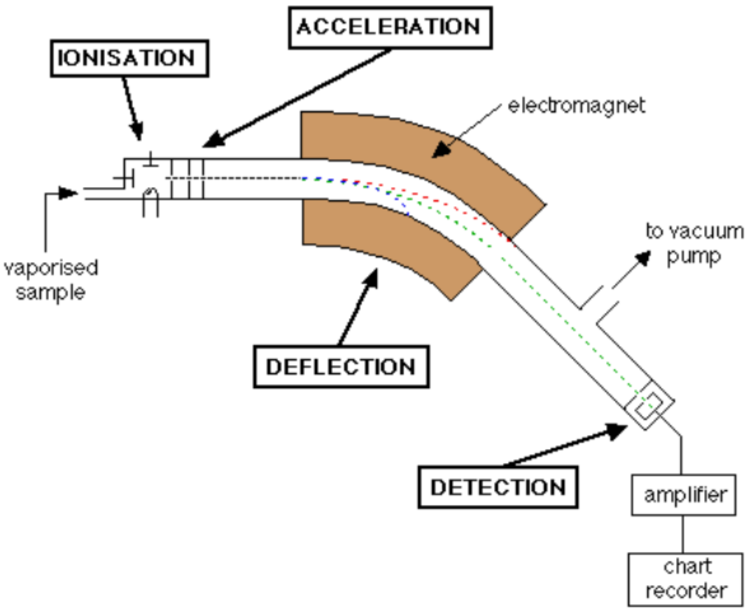
Question 25 (3 marks)

The operational process of a mass spectrometer shown on the figure below is divided into four basic stages:

- Ionisation: The atom is ionised by knocking one or more electrons off to give a positive ion. Mass spectrometers always work with positive ions.
- Acceleration: The ions are accelerated so that they all have the same kinetic energy.
- Deflection: The ions are deflected by a magnetic field according to their masses. The lighter they are, the more they are deflected. The amount of deflection also depends on the number of positive charges on the ion. The more the ion is charged, the more it gets deflected.
- Detection: The beam of ions passing through the machine is detected electrically.



Describe how the principles that determine the behaviour of charged particles in fields enable the operation of a mass spectrometer. **3**

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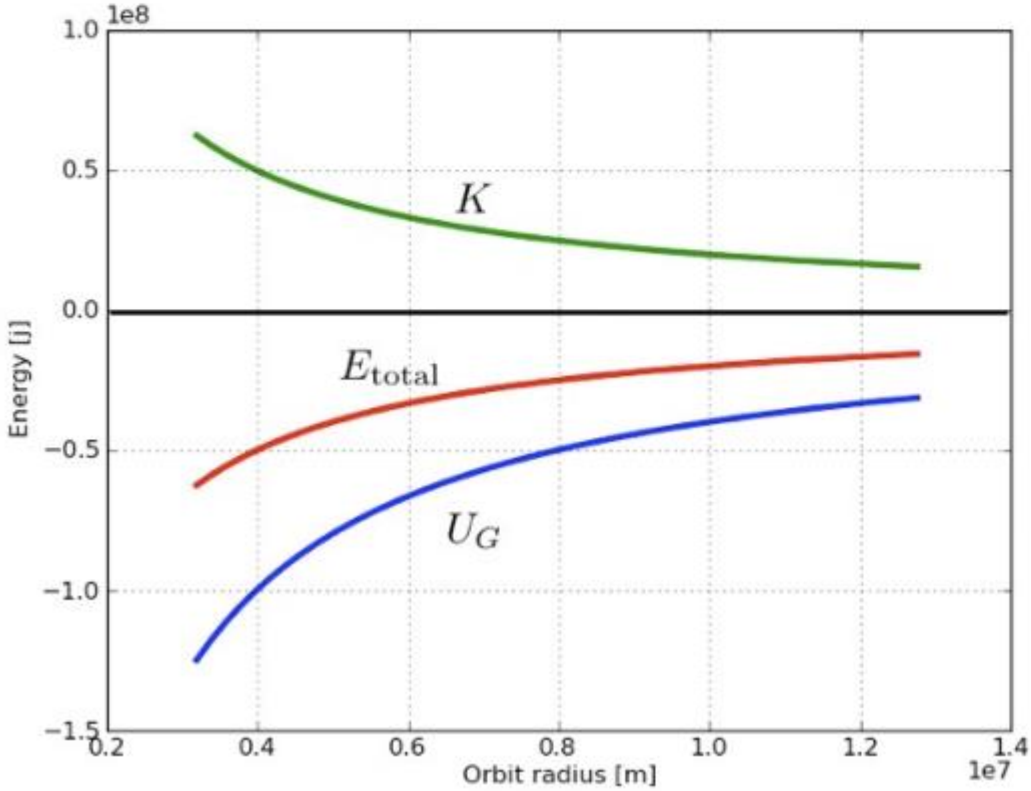
Question 26 (3 marks)



The graph shows the energy changes that occur when a space craft moves between stable circular orbits at different altitudes.
Docking or joining spacecraft together is a common occurrence. The time to successfully do so takes from 2 days to 6 hours. Spacecraft often move from a higher orbit to a lower orbit in order to do this efficiently. Describe the sequence of forces that would need to be applied to move a spacecraft in a higher stable circular orbit to a lower stable orbit in order to dock safely with another spacecraft. **3**

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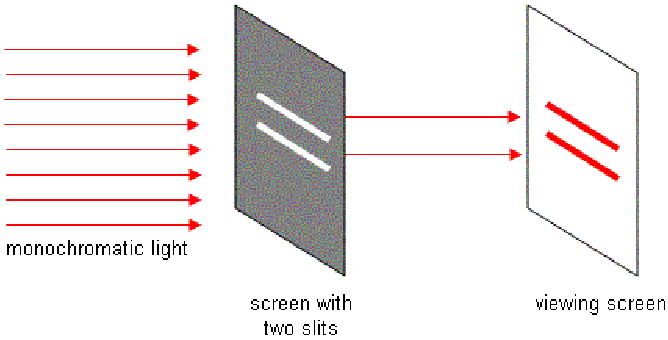
Question 27 (3 marks)

As part of an investigation of light a yellow light of wavelength 5.7 x 10^{-7} m from a sodium lamp is used as a monochromatic source. This is then aimed at a double slit engraved into a black slide and the interference pattern it produces is observed on a screen at a distance 20cm from the slits. **3**



A student measures a distance of 3.89 mm between the centres of each of five consecutive interference fringes. Calculate the slit separation distance on the slide and justify the method of slit separation determination.

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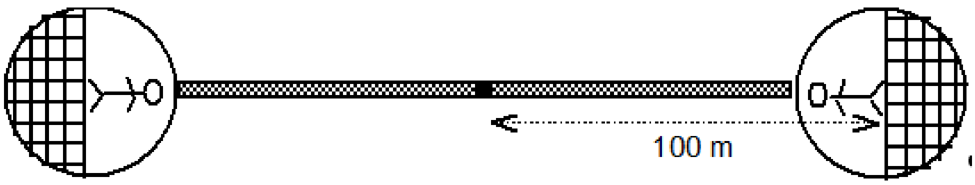
Question 28 (3 marks)

(a) A space station has the shape of a doughnut. The distance from the centre of the hole to the centre of the ring of "dough" is 100 m. With what speed must it be made to rotate so that a spaceman living in the "dough" experiences the same magnitude acceleration as on the surface of the Earth? **2**



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(b) If the angular velocity of the space station is changed to $0.3\ rad\ s^{-1}$ will the inhabitants have an apparent weight gain or loss? Justify your answer. **1**

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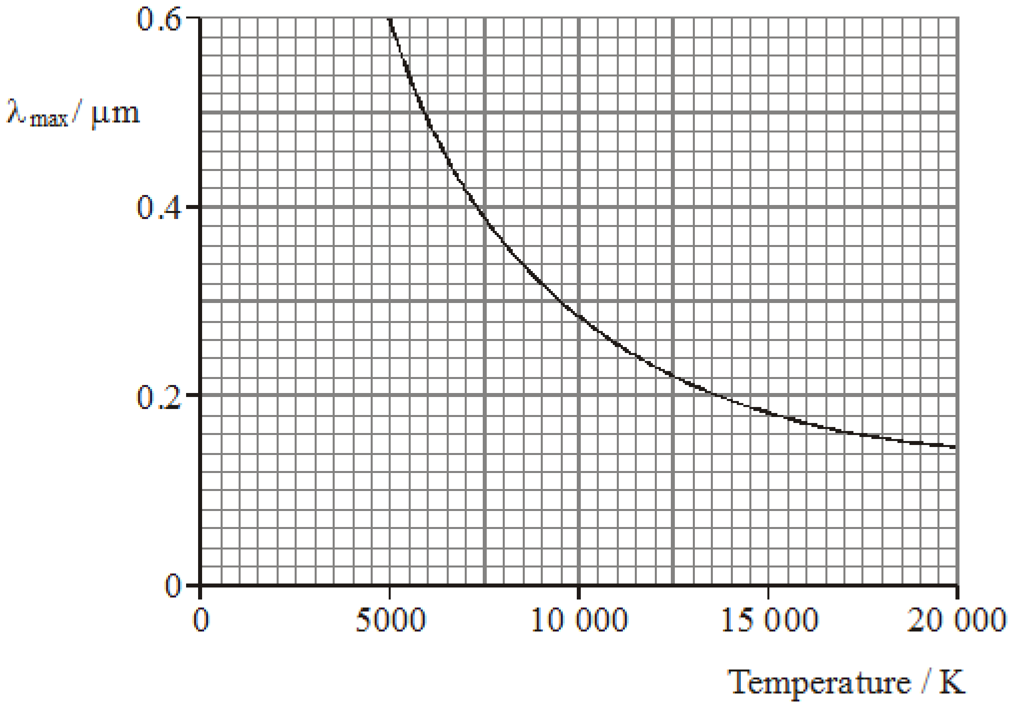
Question 29 (5 marks)

The graph shows how λ_{max} (the wavelength of the peak of the radiation spectrum) for a range of stars varies with the surface temperatures of the stars.



(a) Use the graph to estimate the surface temperature of a star whose intensity peaks at a wavelength of 0.4 µm. **1**

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(b) Using data from the graph, perform appropriate calculations that would support the data from the graph reflecting Wien's Law. **4**

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Question 30 (5 marks)

(a) Discuss the importance of James Clerk Maxwell's contribution to the classical theory of electromagnetism. **3**

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(b) Describe two supporting observations that provided confirmation of Maxwell's contribution to understanding electromagnetic waves. **2**

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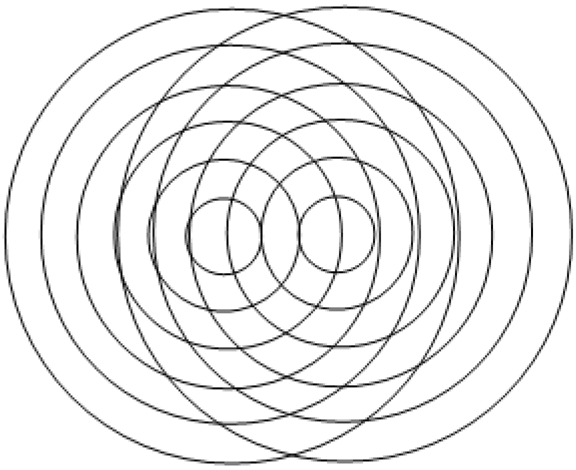
Question 31 (5 marks)

One of the most famous experiments that supported the wave model of light was Young's double slit experiment. This experiment enables the observation of one of light's wave properties (interference) and the collection of quantitative data about light.

(a) The diagram below shows two sources separated by exactly 3 wavelengths emitting waves in phase. Clearly indicate on the diagram with a heavy dot the zones of maximum reinforcement, where the path difference between the waves is 2λ. **2**



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(b) Outline three safety concerns addressed during your quantitative investigation using a double slit apparatus. **3**

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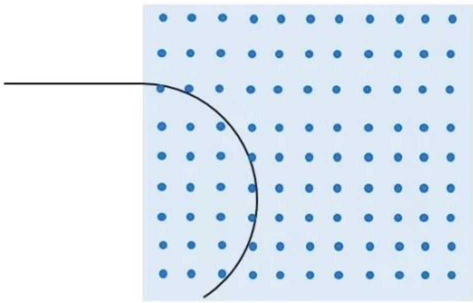
Question 32 (5 marks)

The path followed by a positive ion entering a uniform magnetic field is shown in the figure below.



Positive ions travelling with the same velocity enter a uniform magnetic field initially at right angles to the field.

(a) If two of the ions have equal masses but different charges, identify whether the ion with a smaller or larger positive charge will move in a path with a larger radius. Justify your identification. **3**

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(b) If a positive ion is travelling with a velocity of 5.0×10^7 m s^{-1} and the magnetic field is of intensity 3.5×10^{-3} T, determine the magnitude of the force per unit charge acting on the ion. **2**

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Question 33 (6 marks)

(a) If friction is not able to provide any of the force for the centripetal acceleration of a car on a banked curve, show with the aid of a labelled diagram that the banking angle θ for a radius of curvature R and speed v is independent of the mass of the vehicle and is given by

$$tan\Theta = \frac{v^2}{Rg}$$

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(b) Discuss the implications of the relationship $tan\Theta = \frac{v^2}{Rg}$ on road design. **3**

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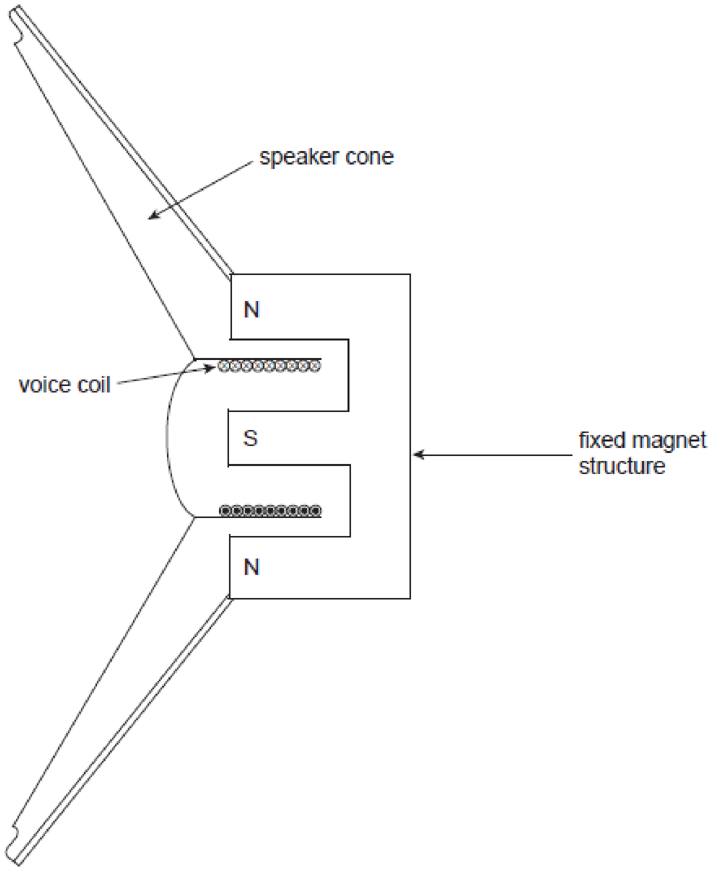
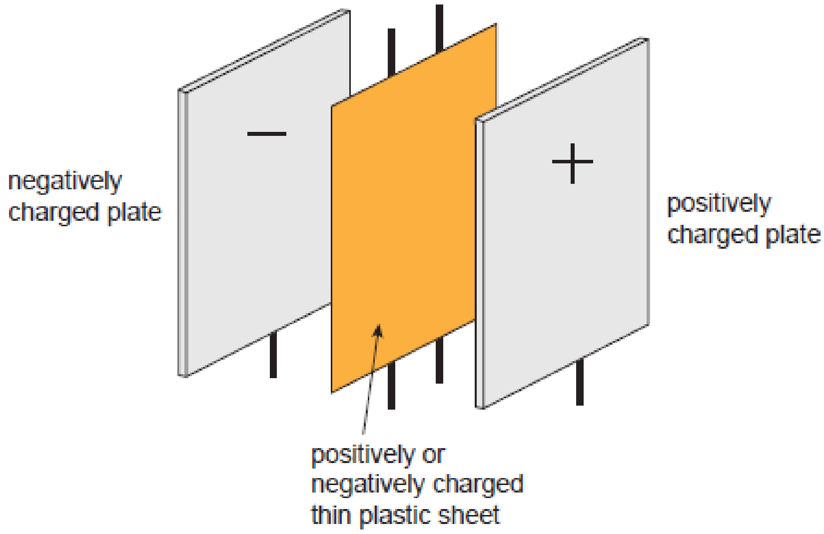
Question 34 (6 marks)

A loudspeaker shown in the figure below uses a fixed magnet and a moveable alternating current carrying coil to produce sound.



An electrostatic speaker shown in the figure below utilises an electric field across two fixed outer plates and a varying charged central sheet that is free to vibrate to produce sound.



(a) Compare and describe the physical principles that enable the operation of the magnetic and electrostatic loudspeaker. **3**

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(b) Contrast the physical principle of operation of a loudspeaker with the operation of an induction motor. **3**

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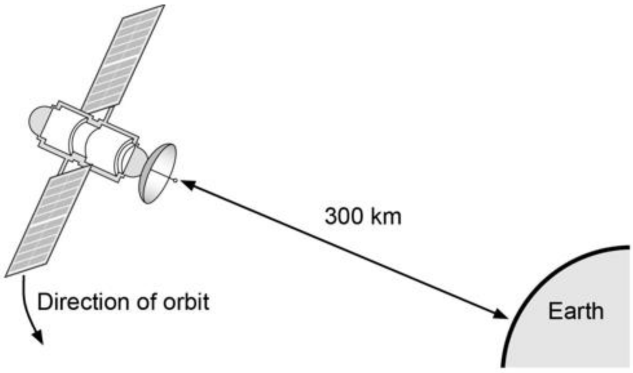
Question 35 (7 marks)

A 10 kg satellite is placed into an orbit at an altitude of 300 km.



(a) Identify the nature of that orbit. **1**

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(b) Calculate the orbital period of the satellite. **2**

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(c) Describe the properties of the orbit of this satellite that would make it useful for identified potential applications. **4**

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Question 36 (8 marks)

The CERN physics program uses powerful accelerators and detectors to study fundamental particles. The laboratory has had to innovate to keep up with electrical demands as CERN uses 1.3 terawatt hours of electricity annually, enough power to fuel 300,000 homes for a year. Much of that power is consumed when the accelerator is in operation accelerating protons. Each proton in the Large Hadron Collider has around 7×10^{12} eV of kinetic energy and is smashed into another proton travelling in the opposite direction with the same energy.

(a) Determine the total momentum of two colliding protons with energies of 7×10^{12} eV in the LHC? Justify your answer. **2**

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(b) Calculate the relativistic momentum of a proton travelling at 0.999999991c. **2**

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(c) The Large Hadron Collider at CERN has a radius of 26 659 m. If a proton has a maximum energy of 7×10^{12} eV this results in 11245 revolutions around the CERN ring per second. Determine the angular velocity of the protons. **2**

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(d) The large hadron collider seeks among other things, to give clarity to aspects of the Standard Model of matter. Part of that model includes quarks and the quark composition hadrons. Describe the relationship between quarks and the quark composition hadron, the proton, in the Standard Model. **2**

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Question 37 (9 marks)

As part of a depth study an investigation was conducted to determine a value for Planck's constant. The experiment involved setting up five individual, single frequency light emitting diodes (LEDs). Each LED only emits one frequency of light when a turn on voltage (V_0) above a certain threshold value is applied across its terminals.
The relationship between the frequency of the emitted light and the voltage (V_0) is given by the equation below.
$E = hf = q_e(V_0 + k)$ where
h is Planck's constant, f is the frequency of light emitted by the diode, q_e is the charge on an electron, V_0 is the turn on voltage, k is the threshold voltage that is a constant dependent on the material.

The experiment produced the following results.

LED colour	Maximum wavelength (λ) (nm)	Turn on voltage(V_0)	1/λ (m^{-1})
Blue	450	2.53	
Green	550	2.04	
Yellow	570	1.88	
Red	690	1.37	
Infra-red	890	0.88	

(a) Complete the table above for calculated values of 1/λ. **2**

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(b) Plot a graph of voltage against $1/\lambda$, and draw the line of best fit. **2**

(c) Use the graph to calculate the gradient of the line of best fit. **2**
Show all construction lines.

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(d) Use the calculated gradient and the provided equation ($E = hf = q_e(V_0 + k)$) to calculate a value for Planck's constant and comment on the accuracy of the procedure.. **3**

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Student Name:……………………………..

PHYSICS – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

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

QATs

Quality Assessment Tasks

2019 Higher School Certificate
Trial Examination
Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Identifies that light is a quantity that has its velocity determined by definition • Clearly describes how the defined velocity can be used as a means to determine a distance given a period of time of travel	3
• Clearly describes how light with a known defined velocity can be used to determine a distance	2
• Identifies that the metre is based on the distance light travels in a defined time	1

Sample answer

The speed of light in a vacuum has a fixed velocity, from which all observers can define their own length scale. This means that there is no need to measure the speed of light because it is defined. If the velocity is known, then the distance that light travels in a specific period of time is a known distance. The metre is a unit of length defined by how far light travels in a well-defined period of time.

Question 22

Criteria	Marks
• A correct determination of the strength of the magnetic field on the deuteron	3
• A correct determination of the mass of a deuteron and the F_c on the particle	2
• A correct determination of the mass of a deuteron or the F_c on the particle or a recognition that the force due to the magnetic field on the deuteron is equal to the centripetal force on the deuteron	1

Sample answer

Mass of a deuteron = $M_n + M_p$

Mass of a deuteron = 1.675×10^{-27}kg + 1.673×10^{-27}kg

Mass of a deuteron = 3.348×10^{-27}kg

Now since the deuteron is travelling in a circular path the centripetal force supplied to the deuteron to keep it in its circular motion in the accelerator is equal to the force due to the magnetic field on the charged deuteron at velocity.

$$F_c = F_B$$

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

$$B = \frac{mv}{qr} = \frac{3.348 \times 10^{-27} \times 9 \times 10^6}{0.5 \times 1.6 \times 10^{-19}}$$

$$B = 0.37665\ T$$

Question 23
23(a)

Criteria	Marks
• A correct determination of the wave frequency and substitution to find the energy of the photon	2
• A correct determination of the wave frequency or substitution to find the energy of the photon	1

Sample answer

$$C = f\lambda$$
$$f = \frac{C}{\lambda}$$
$$f = \frac{3 \times 10^{8}}{510.9 \times 10^{-9}}$$
$$f = 5.8754 \times 10^{14}$$

Now

$$E = hf = 6.626 \times 10^{-34} \times 5.8754 \times 10^{14} = 3.8931 \times 10^{-19} J$$

23(b)

Criteria	Mark
• A correct determination of the work function	1

Sample answer

$$\varphi = hf - KE_{max} = 3.8931 \times 10^{-19} - 5.36 \times 10^{20} = 3.357 \times 10^{-19} J$$

Question 24

Criteria	Marks
• A correct response showing calculations	3
• A correct determination of the radius of satellite orbit in metres with an incorrect substitution or an incorrect determination of the radius of satellite orbit and a correct substitution	2
• One relevant correct calculation	1

Sample answer

Since the ISS orbits 4.00 x 10^2 km above Earth's surface, the radius at which it orbits is the radius of the Earth + 4.00 x 10^2 km. Hence its orbital velocity is

$$v_{orbit} = \sqrt{\frac{GM_E}{r}} = \sqrt{\frac{6.67 \times 10^{11} \times 6.0 \times 10^{24}}{6.371 \times 10^{6} + 4 \times 10^{5}}} = 7.69 \times 10^{3} ms^{-1}$$

Question 25

Criteria	Marks
• Applies a thorough understanding of the behaviour of charged particles in electric and magnetic fields to explain the operation of the mass spectrometer including repulsion and attraction leading to the acceleration and focusing (electric field) and repulsion (magnetic field) leading to the separation of charged particles proportional to their mass before eventual detection by an attraction at the detection electrode	3
• Applies a limited understanding of the behaviour of charged particles in electric and magnetic fields to explain the operation of the mass spectrometer including repulsion and attraction leading to the acceleration and focusing (electric field) and repulsion (magnetic field) leading to the separation of charged particles proportional to their mass before eventual detection by an attraction at the detection electrode	2
• Identifies one correct relevant charged particle behaviour due to an electric or magnetic field interaction	1

Sample answer

The vapourised particles are charged by stripping an electron then accelerated through a set of electrodes to focus the stream of charged particles into a beam that is accelerated toward a detector. A magnetic field is used to separate the beam into components by creating a force on the charged particle at right angles to the magnetic field giving a circular path. Separation according to mass occurs because m is proportional to the radius and this ensures that only ions of the investigated mass are accelerated toward the oppositely charged detector. Masses too big or small follow a different path and are not detected.

Question 26

Criteria	Marks
• Applies a deep understanding of energy in a gravitational field to establish a link between KE and altitude and communicates succinctly s sequence that would enable docking	3
• Applies a deep understanding of energy in a gravitational field to establish a link between KE and altitude and communicates in general terms a that would enable safe docking	2
• Demonstrates a relevant force applied to the satellite that is required without connecting the force to a change in KE or GPE	1

Sample answer

Change in energy of the spacecraft is given by

$$\Delta E = \frac{1}{2} G m M_E \left(\frac{r_2 - r_1}{r_1 r_2} \right)$$

Where the lower orbit is r_2 and the higher orbit is r_1

That means the change in energy is negative.
The only way to make the work done negative would be to have a force from your rockets) in the opposite direction as the way you are going. Your speed would then increase from the velocity equation meaning KE would increase.

$$\Delta v = \sqrt{G M_E \left(\frac{r_1 - r_2}{r_1 r_2} \right)}$$

To safely dock you would have to overshoot and catch the spacecraft at a lower orbit as you chase it at a higher velocity. On approach to the craft which is in a higher orbit you would then need to go to the higher orbit so would need to fire your rockets in a positive direction to go higher so you slow down and catch up to the rocket at a velocity just above its velocity.

Question 27

Criteria	Marks
• A correct response showing relevant calculations recognising the contribution of superposition of waves with different path length as a clear justification	3
• A correct response showing relevant calculations without a clear justification	2
• A correctly applied relevant calculation	1

Sample answer

Both slits provide a source of light. The difference in the path length for an adjacent maximum must be a single whole wavelength to produce constructive interference. If the first maximum from the central maximum is considered, the angle θ can be determined by trigonometry.

$$tan\theta = \frac{3.89 \times 10^{-3}}{2 \times 10^{-1}}$$
$$\theta = 1.1142624°$$

Now

$$dsin\theta = m\lambda$$
$$d = \frac{m\lambda}{sin\ 1.1142624}$$
$$d = \frac{5.7 \times 10^{-7}}{sin\ 1.114262}$$
$$d = 2.93 \times 10^{-5}\ m$$

Slit separation is $2.93 \times 10^{-5}\ m$.

Question 28
28 (a)

Criteria	Marks
• Equates circular motion to the supply of artificial gravity and calculates a correct response	2
• Equates circular motion to gravity	1

Sample answer

Floor of craft must exert the force on the space station inhabitant necessary to make them move in circular motion. They will then rotate with the same angular velocity as the "dough" and have an acceleration of magnitude. If the acceleration must be the same as on the surface of the Earth it must be 9.8 ms^{-2}.

$$a_c = \frac{v^2}{r}$$

Solving for v

$$v = \sqrt{a_c \times r}$$
$$v = \sqrt{9.8 \times 100}$$

$$v = 31.3\ ms^{-1}$$

28 (b)

Criteria	Mark
• A correct calculation of the new apparent centripetal acceleration and a justification for an apparent weight loss	1

Sample answer

$a_c = \omega^2 r = 0.3^2 \times 100 = 9ms^{-2}$ is the apparent gravity supplied by the centripetal acceleration..

Since the centripetal acceleration is supplying the apparent gravity and is now less than 9.8 ms^{-2} the inhabitants would experience an apparent loss of weight because $F_w = m \times g_{apparent}$

Question 29
29 (a)

Criteria	Mark
● Extracts data from the graph to reflect a correct value	1

Sample answer

$7250°C$

29 (b)

Criteria	Marks
● Applies the equation for Wien's Law correctly to calculate a value for at least two temperatures that concur with wavelength data read directly from the graph, including using correct adjustments of units	4
● Applies the equation for Wien's Law correctly to calculate a wavelength value at a at least two temperatures that concur with wavelength data read directly from the graph without using correct units	3
● Applies the equation for Wien's Law correctly to calculate a value at one temperature that concur with wavelength data read directly from the graph including using correct adjustments of units	2
● Applies the equation for Wien's Law correctly to calculate a value at one temperature that concurs with wavelength data read directly from the graph	1

Sample answer

$\lambda_{max} = \frac{b}{T}$

$$\lambda_{max} = \frac{2.898 \times 10^{-3}}{20000}$$

$\lambda_{max} = 1.449 \times 10^{-7}$ m

From the graph $\lambda_{max} = 0.145\ \mu m$
This supports Wien's Law.

$$\lambda_{max} = \frac{b}{T}$$
$$\lambda_{max} = \frac{2.898 \times 10^{-3}}{10000}$$
$$\lambda_{max} = 2.898 \times 10^{-7}\ m$$

From the graph $\lambda_{max} = 0.290\ \mu m$
This supports Wien's Law.

Question 30
30 (a)

Criteria	Marks
• Demonstrates an extensive knowledge of the science areas linked by Maxwell and his theory of electromagnetism and its importance to understanding a range of observations across a number of disparate fields	3
• Demonstrates a limited knowledge of the science areas linked by Maxwell and his theory of electromagnetism and its importance to understanding a range of observations across a number of disparate fields	2
• Demonstrates a limited knowledge of the science areas linked by Maxwell and his theory of electromagnetism or its importance to understanding a range of observations across a number of disparate fields	1

Sample answer

James Clerk Maxwell developed his classical theory of electromagnetic radiation, which brought together electricity, magnetism and light as different manifestations of the same phenomenon. Maxwell's equations accurately and completely describe electromagnetism. They form the foundation of classical electromagnetism, classical optics and electric circuits. Maxwell's equations describe how electric charges and electric currents create electric and magnetic fields. Further, they describe how an electric field can generate a magnetic field, and vice versa.

30 (b)

Criteria	Marks
• Identifies two relevant observations predicted by Maxwell and his equations relating electricity and magnetism in electromagnetic waves	2
• Identifies one relevant observation predicted by Maxwell and his equations relating electricity and magnetism in electromagnetic waves	1

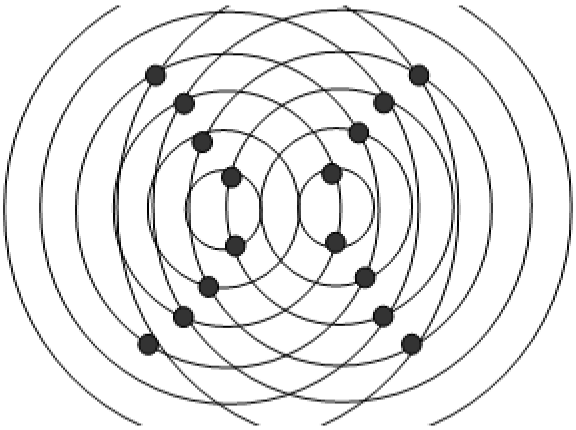
Sample answer

Maxwell predicted from his mathematical equations the velocity of light and it was correct at $3 \times 10^8 ms^{-1}$.
Maxwell predicted other types of electromagnetic waves other than visible light.
These other types of electromagnetic waves were identified, for example, radio waves.

Question 31
31 (a)

Criteria	Marks
• A complete and correct representation drawn on the diagram	2
• An incomplete correct representation drawn on the diagram	1

Sample answer



31 (b)

Criteria	Marks
• Identifies three hazards and their mitigation or elimination that could reasonably be encountered when conducting the investigation	3
• Identifies two hazards and their mitigation or elimination that could reasonably be encountered when conducting the investigation	2
• Identifies one hazard and its mitigation or elimination that could reasonably be encountered when conducting the investigation	1

Sample answer

The investigation was conducted in a darkened room, so care was taken not to avoid trip hazards in the dark. We used a low power laser (<1 milliwatt) as the light source as high-power lasers could result in hazards such as burning. Care was taken to avoid the beam entering anyone's eyes including those that might occur due to a stray reflection and a laser in use hazard sign was placed on the door of the room to warn others that a laser was in use.

Question 32
32 (a)

Criteria	Marks
• Equates the force due to a charged object in a magnetic field to the centripetal force and recognises that will lead to a greater force on the larger charged ion with minimal difference in mass hence causing it to move with a tighter radius with a clear justification	3
• Equates the force due to a charged object in a magnetic field to the centripetal force and recognises that will lead to a greater force on the larger charged ion with minimal difference in mass hence causing it to move with a tighter radius	2
• Identifies that the larger charged ion will move with a tighter radius in the magnetic field	1

Sample answer

The force on a particle with charge q entering the magnetic field B with a velocity v is determined by $F = Bqv$. But if the charge is doubled then the force becomes $F = B2qv$. Since both charges have a common velocity at entry into the magnetic field the force on the ion with the larger charge is twice as big. This force $F_c = \frac{mv^2}{r}$ is applied on the charged ions giving them a centripetal like motion as it is applied at 90 degrees to the velocity direction at any time. If the centripetal force experienced by the ion with the larger charge particle is doubled (yet the mass is almost constant for both ions as an electron has only a small mass) and since the velocities are kept constant, the radius of the motion must be halved. Hence the ion with the larger charge will have the smaller radius motion in the magnetic field.

32 (b)

Criteria	Marks
• A correct calculation with correct units	2
• An appropriate calculation with a substitution error or without units	1

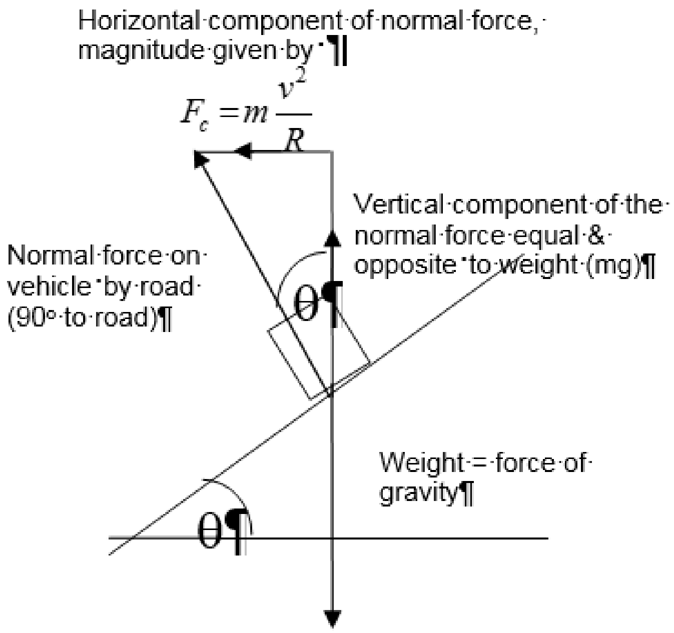
Sample answer

$\frac{F}{q} = qv = 5 \times 10^7 \times 3.5 \times 10^{-3} = 175000\ NC^{-1}$

Question 33
33 (a)

Criteria	Marks
• Draws an appropriate diagram to identify the forces applied to a vehicle on a banked curve and uses vector analysis to correctly derive the banked curve equation	3
• Draws an appropriate diagram and recognises the forces applied to a vehicle on a banked curve	2
• Identifies the forces on a vehicle on a banked curve or draws an appropriate diagram	1

Sample answer



In the right angled triangle,

$$\tan\Theta = \frac{mv^2}{R} / mg = \frac{v^2}{R} / g = \frac{v^2}{Rg}$$

33 (b)

Criteria	Marks
• Applies the formula variables to discuss why the curve recommendation speed limits are independent of vehicle mass if the angle of banking and radius of curvature are known and highlights that the tighter the curve the steeper the angle of banking required	3
• Applies the formula variables to discuss why the curve recommendation speed limits are independent of vehicle mass if two of the following are discussed - the angle of banking - radius of curvature are known and - highlights that the tighter the curve the steeper the angle of banking required	2
• Discusses in general terms an implication of the formula to curve speed limit recommendations	1

Sample answer

The equation is independent of mass and only relies on the speed of the vehicle and radius of curvature of the bend for a given gravitational field. Since the gravitational field is constant (or very nearly constant) the speed limit recommended for any curve where the angle of banking is known, and radius of curvature is known, can be set without thought for the difference in mass of vehicles.

Question 34
34 (a)

Criteria	Marks
• A detailed response identifying sound as a compression wave and linking the attraction of unlike magnetic and electrical polarities and repulsion of like polarities to the operation of each type of speakers with a clear link between the amplitude and frequency of sound produced and the amplitude and frequency of the alternating current in both devices	3
• Two relevant comparison	2
• One relevant comparison	1

Sample answer

	Electrostatic speaker	Magnetic speaker
Vibrating mechanism producing a compression wave.	Central plastic sheet moving back and forward applies a force to air compressing it or causing rarefactions.	Speaker cone moving back and forward applies a force to air compressing it or causing rarefactions.
Mechanism producing vibration and frequency of vibration.	Switching electric field polarity rapidly on the central plastic sheet causes the sheet to be attracted and repelled toward one polarity external sheet (positive or negative) depending on the polarity of the central plastic sheet. the vibration is synchronous with the central plastic sheet polarity changes. Like polarity repels, unlike polarity attracts.	Switching alternating current in the voice coil of the speaker creates a rapidly pulsing magnetic field that interacts with the fixed permanent speaker magnet causing the attached speaker cone to vibrate synchronously with the alternating current frequency as like magnetic poles repel and unlike magnetic poles attract.
Amplitude of vibration.	Relative difference in the electric field strength between the internal and external sheets controls the amplitude of vibration and hence the amplitude of sound. Larger field strength differences between the internal and external sheets produce larger vibrations, smaller differences produce smaller vibrations.	Larger currents produce stronger magnetic fields in the speaker coil meaning larger repulsion and larger amplitude on the speaker cone. Smaller electric currents produce smaller magnetic fields on the speaker coil and smaller amplitude vibrations in the speaker cone.

34 (b)

Criteria	Marks
• Identifies the principles of an induction motor operating and compares these principles to that causing the operation of a speaker noting more than two contrasting differences including permanent magnet in a speaker, electromagnet in an induction motor, rotating motion in a motor, vibrating planar motion in a speaker	3
• Identifies the principles of an induction motor operating and compares these principles to that causing the operation of a speaker noting two contrasting differences including permanent magnet in a speaker, electromagnet in an induction motor, rotating motion in a motor, vibrating motion in a speaker	2
• Provides a relevant contrast	1

Sample answer

An induction motor, uses competing electromagnetic fields; the rotor has wires (called windings) wound around the shaft into which a magnetic field is induced (hence induction motor) and the stationary part of the motor (the stator) is energised (more like an electromagnet) causing it to rotate. The current rotates around the stator windings and this establishes a rotating magnetic field. The direction that the magnetic field rotates determines the direction that the rotor will turn, and the strength of the magnetic field determines how much torque the motor has. A speaker uses a permanent magnet and a fluctuating magnetic field produced by an alternating current carrying wire in a speaker coil. The motion produced by the interactions of the coil magnetic field and the permanent magnet is back and forth, not in rotating motion.

Question 35
35 (a)

Criteria	Mark
• Describes the orbit as a low earth orbit (LEO)	1

Sample answer

The satellite is in a low Earth orbit.

35 (b)

Criteria	Marks
• A correct calculation of the orbital period of the satellite	2
• A relevant calculation or an otherwise correct calculation with a substitution error	1

Sample answer

$$r_{satellite} = r_E + 300000\ m$$

$$r_{satellite} = 6.31 \times 10^6 m\ + 300000\ m = \ 6.671 \times 10^6 m$$

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

$$T = \sqrt{\frac{4 \times (6.671 \times 10^6)^3 \times \pi^2}{6.67 \times 10^{-11} \times 6 \times 10^{24}}}$$

$$T = \ 5412\ s$$

35 (c)

Criteria	Marks
• Identifies features of the satellite orbit e.g. close to the Earth's surface, fast moving and predicts possible uses with justifications	4
• Identifies a feature of the orbit e.g. close to the Earth's surface, fast moving and predicts possible uses with justifications or identifies features of the orbit and predicts a possible use with a justification	3
• Identifies a feature of the orbit e.g. close to the Earth's surface, fast moving and predicts a possible use with justification	2
• Identifies a feature of the orbit e.g. close to the Earth's surface, fast moving or predicts a possible use with justification	1

Sample answer

The satellite orbit is a fast-moving low earth orbit (LEO). Possible uses for the satellite could include telecommunications with rapid response times required or as reconnaissance satellites with the capacity to produce high resolution images because of the close distance to the surface possibly including spy networks or for high resolution mapping. The satellite would also move over large areas of the Earth's surface rapidly providing many images closely sequenced.

Question 36
36 (a)

Criteria	Marks
• A correct determination that the total momentum of the colliding protons is zero with an extensive justification that recognises momentum is a vector quantity and that the protons with the same energy must have the same magnitude momentum	2
• A correct determination that the total momentum of the colliding protons is zero without a clear justification that recognises momentum is a vector quantity and that the protons with the same energy must have the same magnitude momentum	1

Sample answer

The total momentum of the collision of the two protons is zero. The protons have the same speed and mass but are travelling in opposite directions. Since momentum is a vector quantity and the direction is opposite but the magnitude of the momentum of each proton is the same, the total momentum must be zero.

36 (b)

Criteria	Marks
• A correct calculation	2
• A correct calculation method with a substitution error	1

Sample answer

$$p_v = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$p_v = \frac{1.673 \times 10^{-27} \times 0.999999991 \times 3 \times 10^8}{\sqrt{\left(1 - \frac{(0.999999991 \times 3 \times 10^8)^2}{(3 \times 10^8)^2}\right)}}$$

$$p_v = 3.7409 \times 10^{-15} kgms^{-1}$$

36 (c)

Criteria	Marks
• A correct calculation including appropriate units of measurement	2
• A correct calculation without appropriate units of measurement	1

Sample answer

$$\omega = 2\pi f = 2\pi \times 11245 = 70564\, rad\ s^{-1}$$

36 (d)

Criteria	Marks
• A detailed description of how a proton is composed of three quarks, with a description of the nature of those quarks leading to a hadron with a charge of +1	2
• A general description of a proton being composed of quarks	1

Sample answer

A proton is a quark composition hadron composed of three quarks. It is hence a baryon. Two up quarks each with electric charge $+\frac{2}{3}$, for a total of $+\frac{4}{3}$ together combine with one down quark with electric charge $-\frac{1}{3}$. Adding these charges together yields the proton with a charge of +1.

Question 37
37 (a)

Criteria	Marks
• Correct completion of the table with appropriate number of significant figures and exponential	2
• Correct integers but incorrect exponential or incorrect number of significant figures	1

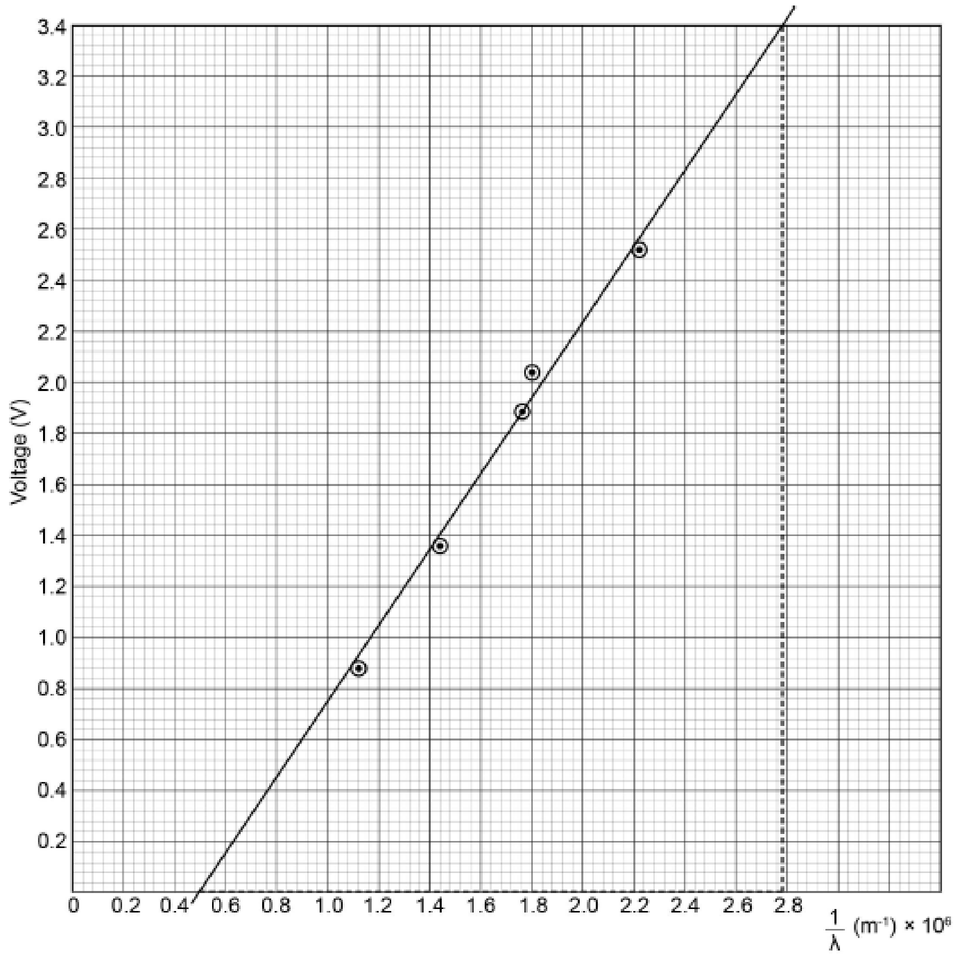
Sample answer

LED colour	Maximum wavelength (λ) (nm)	Turn on voltage(V_0)	$1/\lambda$ (m^{-1})
Blue	450	2.53	2.22×10^6
Green	550	2.04	1.82×10^6
Yellow	570	1.88	1.75×10^6
Red	690	1.37	1.45×10^6
Infra-red	890	0.88	1.12×10^6

37 (b)

Criteria	Marks
• Plot based on responses in the completed table correctly plotted points, axes scales, axes labels <u>and</u> correctly drawn line of best fit	2
• Plot based on responses in the completed table correctly plotted points, axes scales, axes labels <u>or</u> correctly drawn line of best fit	1

Sample answer



37 (c)

Criteria	Marks
• Construction lines on the graph using the full graph or substantial part, correct determination of the gradient based on the drawn graph	2
• Construction lines on the graph using the full graph or substantial part or correct determination of the gradient based on the drawn graph or data in the completed table	1

Sample answer

See graph above for construction lines.
gradient = rise/run= (3.4-0)/(2.78-0.5)= 1.49 V/m

37 (d)

Criteria	Marks
• A correct calculation of Planck's constant from data, realising the relationship between frequency and the wavelength in the wave equation with an appropriate comment on the accuracy of the procedure	3
• A correct calculation of Planck's constant from data, realising the relationship between frequency and the wavelength in the wave equation without an appropriate comment on the accuracy of the procedure	2
• One piece of relevant information or a relevant calculation not already given in the question	1

Sample answer

$E = hf = q_e(V_0)$.
rearranging for h

$$h = \frac{q_e(V_0 + k)}{f}$$

Now $\frac{1}{f} = \frac{\lambda}{c}$
So $h = q_e(V_0)\lambda/c$
and $V_0 \div \frac{1}{\lambda} = \textit{the gradient}$
so $h = q_e \times \frac{gradient}{c} = 1.609 \times 10^{-19} \times 0.00000149/3 \times 10^8 = 7.99 \times 10^{-34} Js$

This value is quite close to the published value of h which is on the data sheet as $6.626 \times 10^{-34} Js$.

2019 Higher School Certificate
Trial Examination
Physics Mapping Grid
Section I

Question	Marks	Content	Syllabus Outcomes
1	1	Mod 7 Light and special relativity	PH12–6, PH12–7, PH12–14
2	1	Mod 5 Projectile Motion	PH12-2, PH12–12
3	1	Mod 8 Quantum mechanical Nature of the atom	PH12–7, PH12–15
4	1	Mod 5 Circular motion	PH12-5, PH12-12
5	1	Mod 5 Circular motion	PH12-4, PH12-5, PH12-12
6	1	Mod 5 Circular motion	PH12-4, PH12-5, PH12-12
7	1	Mod 5 Circular motion	PH12-4, PH12-5, PH12-12
8	1	Mod 5 Motion in gravitational fields	PH12-4, PH12-5, PH12-12
9	1	Mod 7 Light: Wave model	PH12-3, PH12-14
10	1	Mod 6 The motor effect	PH12-4, PH12-5, PH12-13
11	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-2, PH12-13
12	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-2, PH12-4, PH12-13
13	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-2, PH12-4, PH12-13
14	1	Mod 6 Electromagnetic induction	PH12-2, PH12-4, PH12-13
15	1	Mod 6 Motor effect	PH12-5, PH12-13
16	1	Mod 8 Structure of the atom	PH12-5, PH12-15
17	1	Mod 7 Electromagnetic spectrum	PH12-2, PH12-14
18	1	Mod 7 Quantum model	PH12-7, PH12-14
19	1	Mod 8 properties of the nucleus	PH12-6, PH12-15
20	1	Mod 7 Electromagnetic spectrum	PH12-2, PH12-14

Section II

Question	Marks	Content	Syllabus Outcomes
21	3	Mod 7 Electromagnetic spectrum	PH12-7, PH12-14
22	3	Mod 6 Charged particles and electric and magnetic fields	PH12-4, PH12-12, PH12-13
23(a)	2	Mod 7 Light: quantum model	PH12-4, PH12-14
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24	3	Mod 5 Circular motion	PH12-6, PH12-12
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26	3	Mod 5 Motion in gravitational fields	PH12-7, PH12-12
27	3	Mod 7 Light wave model	PH12-1, PH12-2, PH12-14
28 (a)	2	Mod 5 Circular motion	PH12-5, PH12-12
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29(a)	1	Mod 8 Origins of the elements	PH12-5, PH12-6, PH12-15
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30 (a)	3	Mod 7 Electromagnetic spectrum	PH12-4, PH12-7, PH12-14
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