Exam Choice

Student Number

2019

TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours.
- Write using black pen.
- Draw diagrams using pencil.
- For questions in Section II, show all relevant working in questions involving calculations.
- NESA approved calculators may be used.

Total marks: 100

Section I – 20 marks (pages 3 – 12)

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

Section II – 80 marks (pages 13 – 28)

- Attempt questions 21 – 38
- Allow about 2 hours and 25 minutes for this section.

Section I – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this section

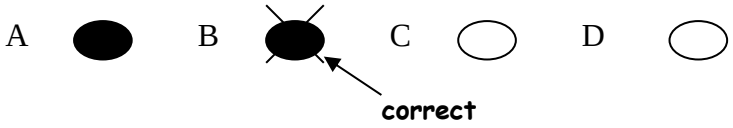
Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



1. Hubble's discovery of the expansion of the Universe was made possible by his observations of:

(A) stellar spectral class.

(B) stellar luminosities.

(C) stellar temperatures.

(D) stellar spectra.

2. An observer on a platform observes a passing train as being shorter than the platform.

At the same time, an observer on board the train measures the platform as being shorter than the train.

This apparent contradiction is explained by:

(A) Einstein's statement that all inertial frames of reference are equally valid.

(B) The train's frame of reference is not valid as it is moving.

(C) Light coming to the observer from the rear of the train is travelling faster than from the front of the train.

(D) Neither of these frames of reference is valid.

3. One of the significant new contributions of Maxwell's equations to the understanding of electromagnetism at the time was:

(A) the link between magnetism and electrons.

(B) the discovery of radio waves.

(C) the prediction of an electromagnetic spectrum.

(D) that light was composed of photons.

4. An ideal transformer where 100% efficiency occurs is not possible as:

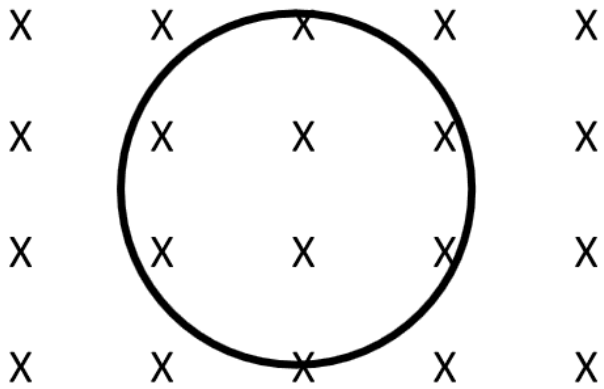
(A) eddy currents produce heat.

(B) the current must also change.

(C) transformers cannot operate using DC.

(D) iron cores are not magnetic.

5. A circular loop of wire stands vertically within a horizontal magnetic field, as shown.



Of the following scenarios, which would produce the average greatest rate of change of magnetic flux through the same circular loop of wire?

(A) Doubling the magnetic field intensity in 10 seconds.

(B) Reducing the size of the loop to zero in 10 seconds.

(C) Laying the loop horizontally in 10 seconds.

(D) Rotating the loop around a vertical axis one full turn every 10 seconds.

6. Curved train tracks are banked so that, to an occupant in the trains:

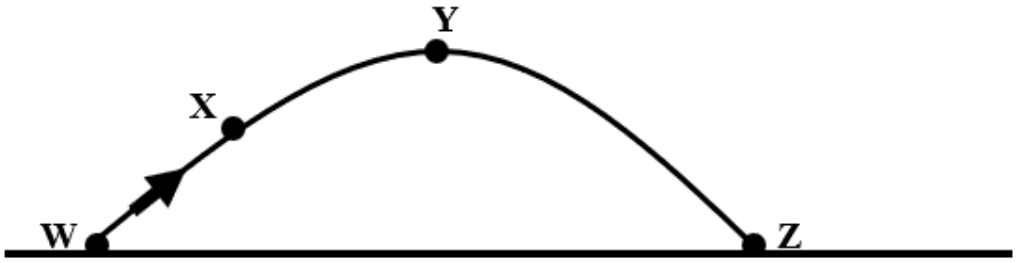
(A) the gravitational force is matched by the required centripetal force.

(B) the centripetal force is equal to the normal force.

(C) the normal force contributes to the required centripetal force.

(D) the normal force aligns with the gravitational force.

7. The flightpath of a projectile fired over level ground is shown:



The projectile has minimum speed at point:

(A) **W**

(B) **X**

(C) **Y**

(D) **Z**

8. Observations of the Balmer series of hydrogen are explained by:

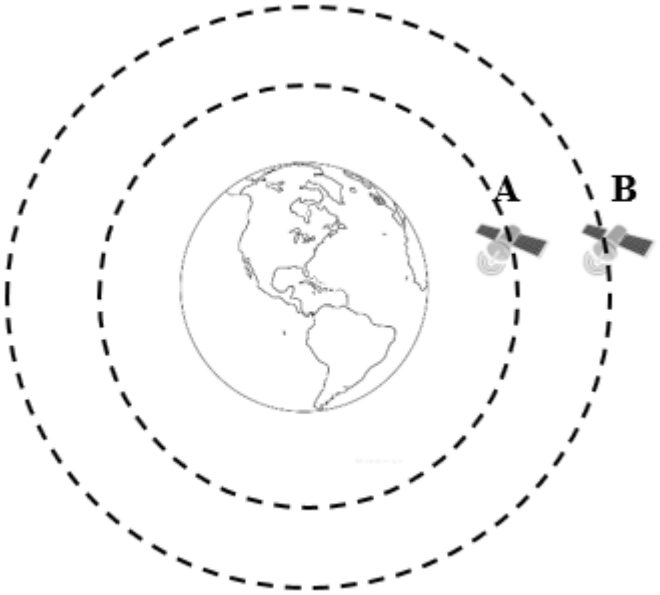
(A) electrons orbiting the nucleus spiralling down and losing energy.

(B) electrons transitioning between energy levels.

(C) radiation from the nucleus.

(D) reflections of light photons from the electrons.

9. Two satellites, **A** and **B** are orbiting Earth at different altitudes, as shown.



Which comparison of the satellites' orbital velocities, orbital periods and centripetal accelerations is correct?

	Orbital velocity	Orbital period	Centripetal acceleration
(A)	A is greater	B is greater	B is greater
(B)	B is greater	A is greater	A is greater
(C)	B is greater	B is greater	B is greater
(D)	A is greater	B is greater	A is greater

10. When an electron and a positron annihilate, the energy released is equal to:

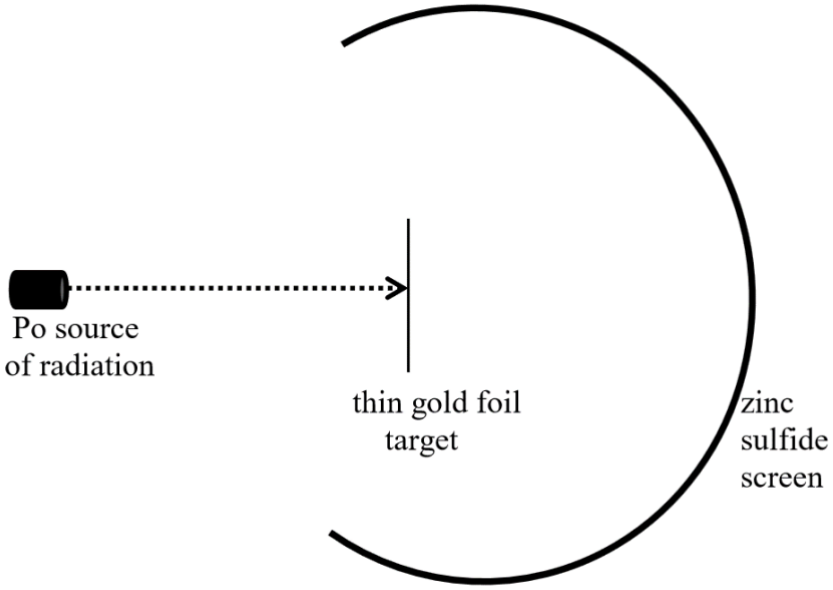
(A) $9.1 \times 10^{-31} \times 3.00 \times 10^{8}$ J

(B) $9.1 \times 10^{-31} \times (3.00 \times 10^{8})^{2}$ J

(C) $(2 \times 9.1 \times 10^{-31}) \times (3.00 \times 10^{8})^{2}$ J

(D) $(2 \times 9.1 \times 10^{-31} \times 3.00 \times 10^{8})^{2}$ J

11. An investigation was set up as shown in the diagram.



The observations made from this investigation led to:

(A) the discovery of the nucleus.

(B) the discovery of the neutron.

(C) the discovery of cathode rays.

(D) the conclusion that electrons are a part of every atom.

12. Two bike riders have a race over a straight track.

The blue bike starts from rest and accelerates uniformly at 2.0 m s^{-2}, while the red bike starts from the same position but with an initial speed of 5.0 m s^{-1} and then accelerates uniformly at 1.6 m s^{-2}.

How far from the start line are the two bikes again side by side?

(A) 25 m

(B) 625 m

(C) 80 m

(D) 32 m

13. In a particle accelerator, a proton is travelling at 0.9999c.

It is then intentionally collided with another proton, travelling in the opposite direction but with the same speed.

What is the primary reason for colliding these two protons?

(A) to measure their masses at such high speeds.

(B) to observe how they repel each other at these speeds.

(C) so that they collide and bounce off each other to observe if momentum is conserved or otherwise.

(D) so that their energy contributes to the formation of new particles.

14. The wavelength of peak intensity radiation emanating from a source with temperature T_1 is measured as λ_1.

The temperature of the body is changed to T_2, where $T_2 = 2T_1$.

What changes in the radiation from the source would be observed?

(A) The peak wavelength would become $2\lambda_1$.

(B) The peak wavelength would become $\frac{\lambda_1}{2}$.

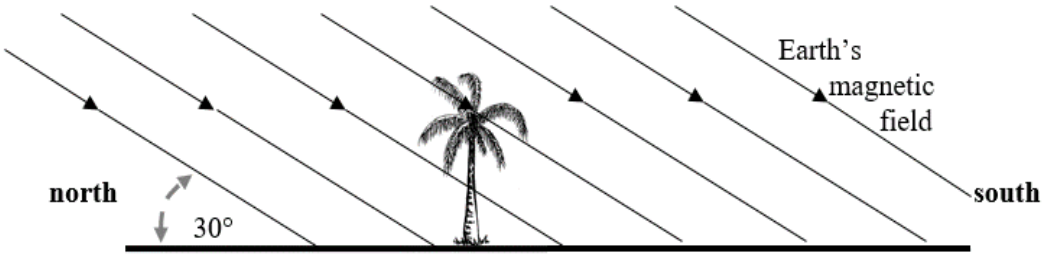
(C) The peak wavelength would remain unchanged.

(D) The peak wavelength would increase a small amount.

15. A student conducts an investigation into the force that acts on a section of a long straight wire.

The wire carries a current and is within a magnetic field.

Where the investigation is performed, Earth's magnetic field is angled at 30° to the horizontal, as shown.



What orientation of the wire results in the maximum force on the section of wire?

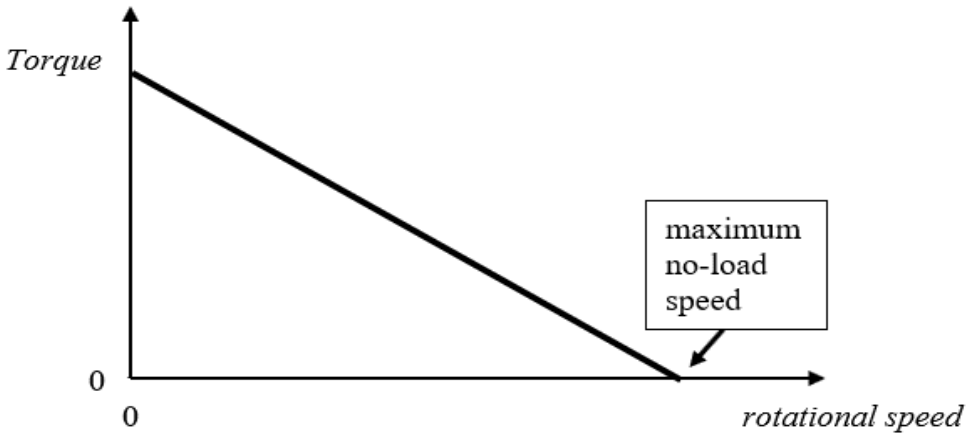
(A) vertical

(B) horizontal and north-south

(C) horizontal and east-west

(D) inclined so it is parallel with the magnetic field

16. A typical DC motor has a torque versus rotational speed curve shown below.



The motor having a maximum rotational speed is due to:

(A) a slight delay in the current reversing in the coils.

(B) back EMF.

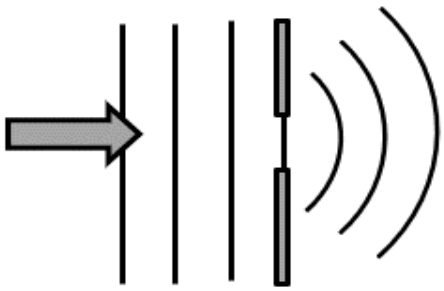
(C) resistance of the coils.

(D) the coils not being sufficiently large.

17. An investigation of diffraction of waves was performed using a ripple tank and obstacles placed in the tank.

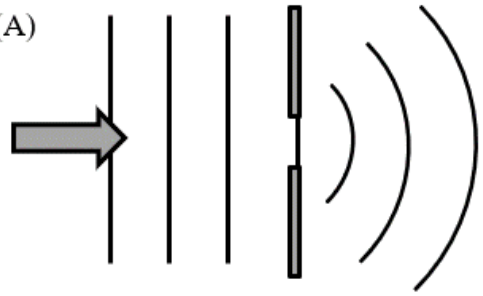
The wavelength and slit width were varied and the results observed.

The original diffraction observations are shown.

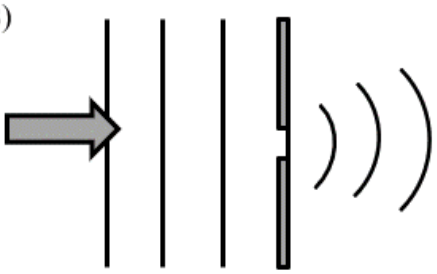


Given the modifications made to the slit width or wavelength, which is the most likely to have been observed?

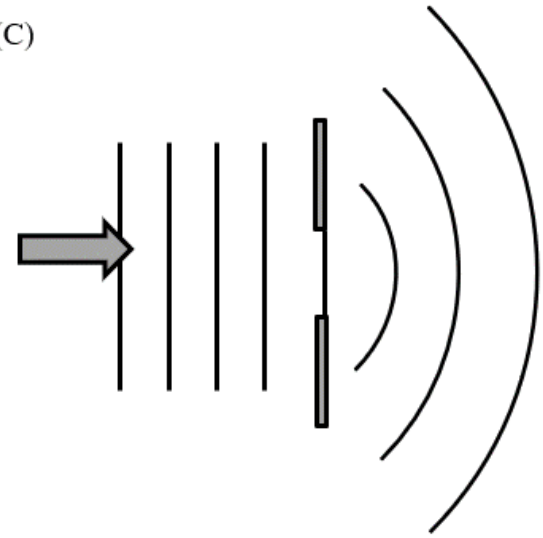
(A)



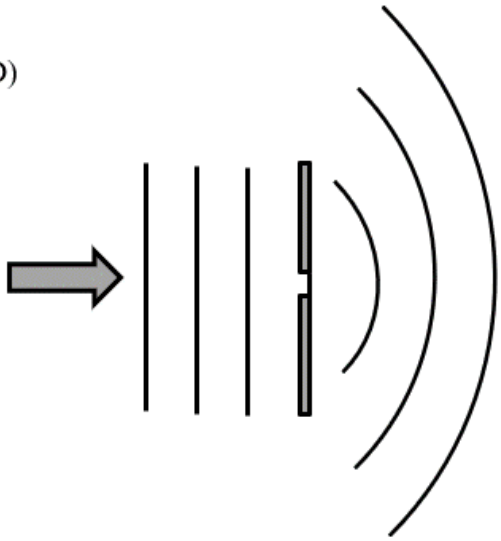
(B)



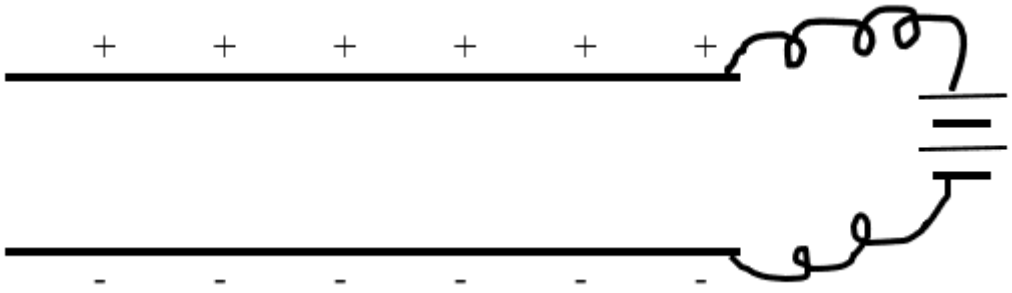
(C)



(D)



18. Two charged parallel plates have a potential difference of 35.0 V, as shown.



How far apart must these two plates be so that a point charge of -4.0×10^{-8} C with a mass of 2.5×10^{-6} kg will be exactly suspended against gravity?

(A) 56 cm

(B) 57 mm

(C) 17.5 m

(D) 1.8 m

19. The total potential energy of a satellite with mass 6.50×10^{3} kg when orbiting Earth at an altitude of 2.00×10^{3} km is closest to:

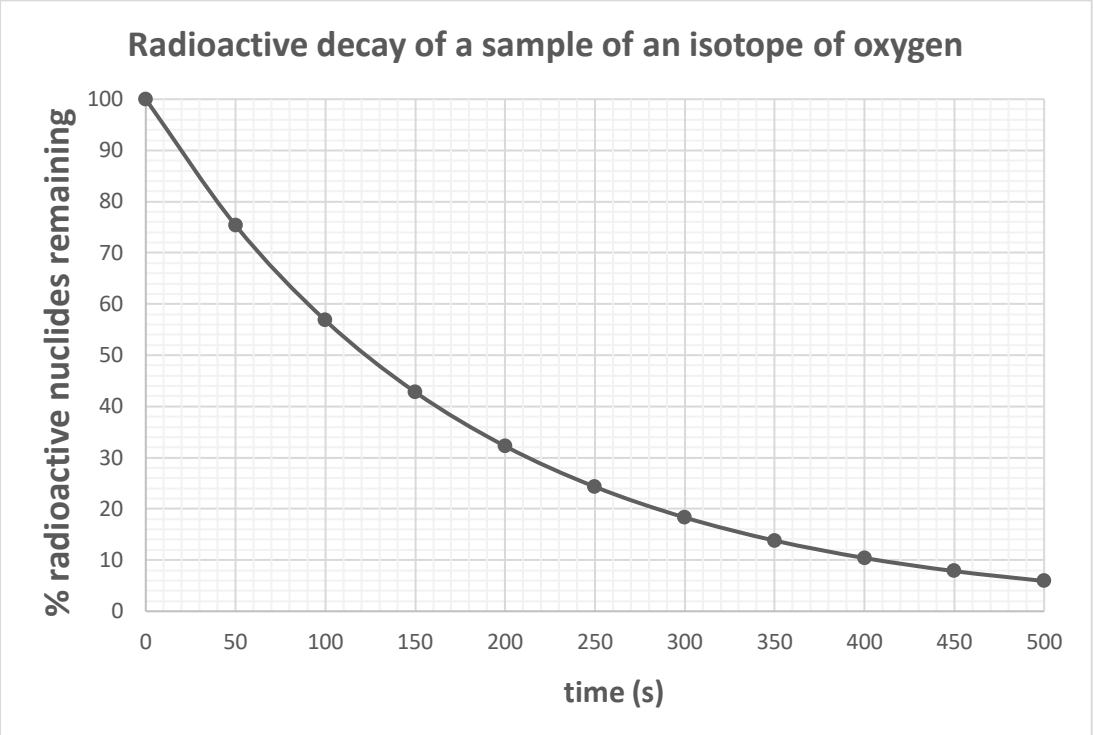
(A) -3.11×10^{11} J

(B) -3.11×10^{14} J

(C) -1.30×10^{15} J

(D) -1.55×10^{11} J

20. The radioactivity of a small sample of an isotope of oxygen was measured over time and the results plotted on the axes shown.



What is the most likely value of the radioactive decay constant?

(A) 125

(B) 50

(C) 0.005658

(D) 0.58

2019 | TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks

Attempt Questions 21 – 38

Allow about 2 hours and 25 minutes for this part

Instructions

- 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.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which questions you are answering.

Marks

Question 21 (5 marks)

Projectile motion can be modelled by analysing the horizontal and vertical components separately. **2**

(a) Show that the maximum height reached by a projectile, h_{max}, is given by:

$$h_{max} = \frac{u^2 \sin^2 \theta}{2g}$$

given: u = initial launch speed; θ = launch angle, and g = acceleration due to gravity.

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(b) A certain projectile is always launched with a speed of 40.0 m s^{-1}.

The projectile must land on a target which is exactly 140.0 m away horizontally from the launch position.

The projectile is launched at an angle of 30°. Find whether the projectile lands on, falls short of, or travels further than the target. **3**

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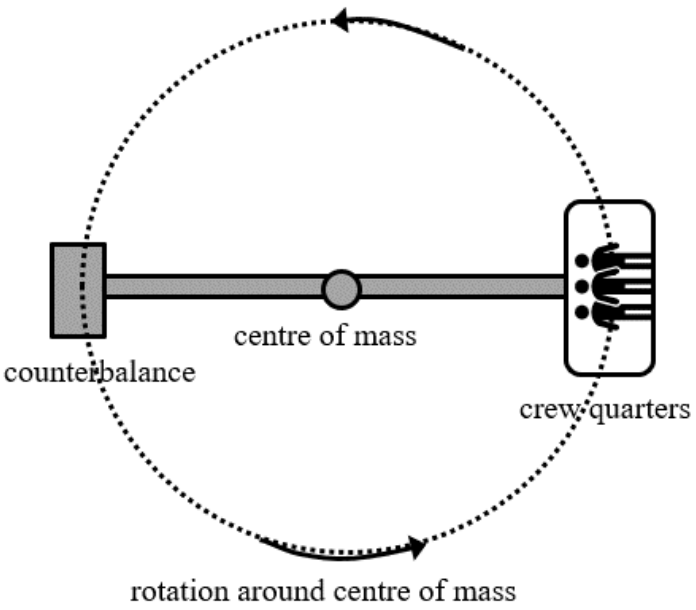
Marks

Question 22 (4 marks)

One solution to the problem of extended periods of time in a weightless environment is to design a spacecraft which is rotating. The rotation will give rise to an "artificial gravity".



Quantitatively derive a viable solution to this problem so that the spacecraft could rotate and the astronauts in the crew quarters would measure an artificial gravitational acceleration of 9.8 m s^{-2}. The period of rotation for the proposed solution cannot be less than one minute, or the astronauts will become disoriented and giddy. **4**

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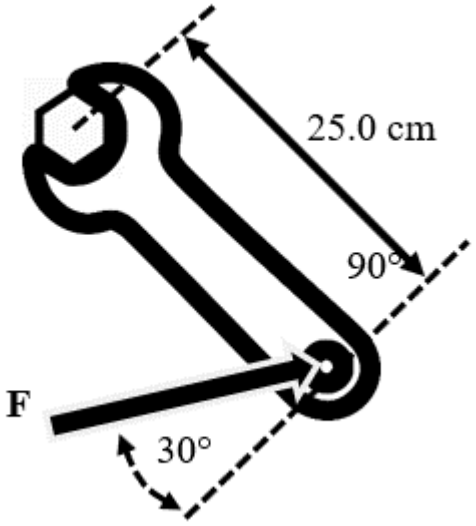
Marks

Question 23 (2 marks)

The torque required to turn a bolt is 200 N m.

Find the force, **F**, required to be exerted on a spanner as shown so that the bolt will turn. **2**



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Marks

Question 24 (9 marks)

The orbits of satellites such as GPS must be known very precisely.

With reference to the total energy of a satellite and Kepler's Laws, discuss how satellites' orbits can be predicted and maintained. **9**

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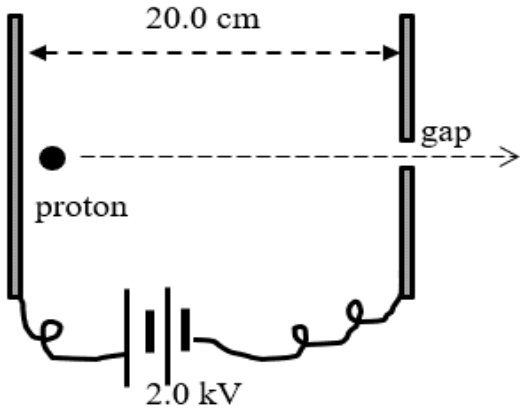
Marks

Question 25 (4 marks)

A single proton is accelerated from rest between two charged plates which have a potential difference of 2.0 kV. The plates are 20.0 cm apart.



The proton's path leads it through the gap in the negatively charged plate.

(a) What is the proton's speed as it passes through the gap in the negatively charged plate? **2**

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(b) Explain why the distance between the two charged plates has no influence on the proton's final speed. **2**

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Marks

Question 26 (5 marks)

Transformers are designed to be as efficient as possible.

Identify the sources of energy loss and justify the design features of a transformer that improve efficiency. Include references to the underlying physics principles which allow transformers to operate. **5**

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Marks

Question 27 (4 marks)

Discuss the relationship between Newton's Third Law of Motion and the SI definition of the ampere. **4**

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Question 28 (4 marks)

Magnetic braking has advantages over conventional friction braking yet the conservation of energy applies to both.

Describe how magnetic braking works and how the conservation of energy applies. **4**

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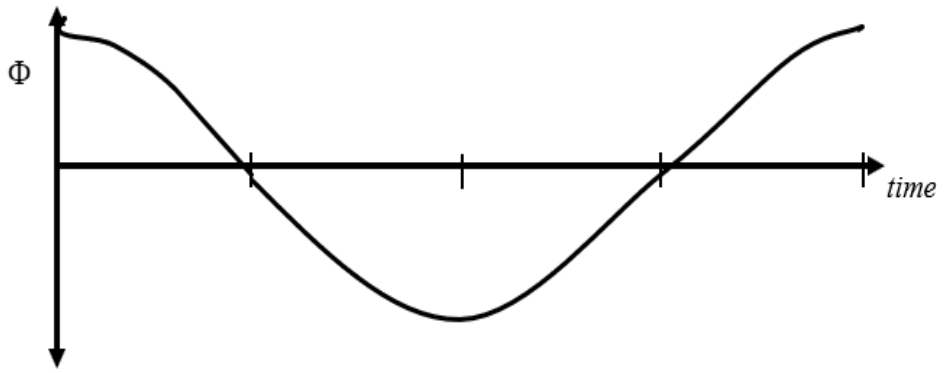
Marks

Question 29 (3 marks)

The graph below shows the magnetic flux, Φ, against time for a rectangular loop of wire rotating within a magnetic field.



(a) On the same axes, sketch and label the shape of the induced EMF versus time. **1**

(b) Describe *one* way in which the induced EMF graph would change if the rectangular loop was rotated faster. **2**

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Marks

Question 30 (9 marks)

Analysis of the spectrum of a star can reveal information about the star, including its surface temperature, rotational and translational velocity, density and chemical composition.

Discuss how our understanding of the production of a star's spectrum and the features they contain has allowed astronomers to reveal this information. **9**

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Marks

Question 31 (5 marks)

Outline a procedure that could be used to perform an investigation in a school laboratory to verify Malus's Law. **5**

Include any diagrams that may be relevant.

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Marks

Question 32 (3 marks)

In an investigation into the photoelectric effect, light of frequency 6.6×10^{14} Hz was directed onto a metal cathode. The stopping voltage was measured as 1.60V.

Find the work function of the cathode metal. Express your answer in eV. **3**

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Q**uestion 33** (3 marks)

Analyse how atomic clocks have been able to verify time dilation as described by Einstein. **3**

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Marks

Question 34 (4 marks)

Nucleosynthesis in main sequence stars can be summarised in the equation:

$$4\ {}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + 2\ {}^{0}_{+1}\mathrm{e} + 2\nu$$

This process must occur in several steps.

Name this process and outline these steps. **4**

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Marks

Question 35 (4 marks)

In determining the charge-mass ratio of cathode ray particles, Thomson showed that these particles were unlike ions or alpha particles.

One part of the experiment involved firing cathode ray particles into a uniform magnetic field, as shown in the diagram.

When the cathode ray particles enter the magnetic field they are deflected in a circular path with a radius of 70.0 mm.

(a) Explain why the shape of the path followed by the cathode ray particles is circular. **2**

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(b) Calculate the speed of these cathode ray particles. **2**

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Marks

Question 36 (3 marks)

Using a typical example and an appropriate equation, show why the deBroglie wavelength of an everyday moving object is not observable. **3**

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Question 37 (5 marks)

It has been calculated that the Sun is emitting 3.86×10^{26} J of radiative energy every second.

(a) How much matter is being converted into energy in the Sun's core each second? **2**

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(b) Given that the mass of a He-4 nucleus is 6.648×10^{-27} kg, calculate how many He-4 nuclei are being produced in the core of the Sun each second. **3**

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Marks

Question 38 (4 marks)

Outline the roles played by the four fundamental forces of nature. **4**

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Section II extra writing space.

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Section II extra writing space.

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Exam Choice

2019 Physics Trial Examination.

Marking Guidelines and Model Answers.

Section I Multiple Choice

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

Section II

21.a.

Marking Criteria	Marks
• calculation of u_y made and used in appropriate formula • further correct assumptions made to show the solution	**2**
• calculation of u_y made	**1**

$u_y = u\sin\theta$

using $v^2 = u^2 + 2as$ for the vertical component of motion:

$v = 0$ at max height,

$s =$ max height ($h_{\max}$)

$a = g$, giving:

$0 = (u\sin\theta)^2 + 2\times -9.8\times h_{\max}$

$$h_{\max} = \frac{u^2\sin^2\theta}{2g}$$

21.b.

Marking Criteria	Marks
• range of projectile is calculated correctly • correct conclusion drawn	**3**
• range of projectile is calculated with an error • corresponding conclusion drawn	**2**
• both vertical and horizontal components of initial velocity found • OR • an appropriate formula employed to find a relevant aspect of the projectile's motion, i.e. either time of flight, horizontal speed	**1**

$u_y = 40\sin 30°$

$= 20 \text{ m s}^{-1}$

$u_x = 40\cos 30°$

$= 34.6 \text{ m s}^{-1}$

Time of flight:

$v_y = u_y + a_y t$

$-20 = 20 - 9.8t$

$9.8t = 40$

$t = 4.08$ s

Range:

range $= u_x \times t$

$= 34.6\times 4.08$

$= 141$ m

So: projectile travels 1m further than target and misses it

22.

Marking Criteria	Marks
• A viable quantitative solution is derived with all calculations evident • Period of rotation of solution exceeds one minute	**4**
• A quantitative solution is found that is not viable	**3**
• A solution is proposed with some quantitative aspects absent	**2**
• A relevant step is shown, e.g. a formula selected	**1**

e.g. Proposed solution: with a radius of 200 m for the spacecraft:
with r = 1000 m; $a_c = 9.8 \text{ m s}^{-2}$:

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

$$v^2 = 9.8 \times 1000$$

$$v = 99.0 \text{ m s}^{-1}$$

$$T = \frac{2\pi \times 1000}{99.0}$$

$$= 63.5 \text{ s (which exceeds one minute)}$$

23.

Marking Criteria	Marks
• Correct answer calculated	**2**
• Appropriate formula used but error(s) made	**1**

$$\tau = rF \sin\theta$$

$$200 = 0.25 \times F \times \sin 60°$$

$$F = \frac{200}{0.25 \times \sin 60°}$$

$$= 924 \text{ N}$$

24.

Marking Criteria	Marks
• Shows a comprehensive understanding of the orbits of satellites • Relates Kepler's Laws to modern energy considerations of orbits • Sources of energy loss/threats to stable orbit, and how these are dealt with is considered • Describes how these factors allow for the accurate prediction of satellites' orbits	**9**
• Shows a sound understanding of the orbits of satellites • Relates Kepler's Laws to some modern energy considerations • Outlines how most of these factors allow for the accurate prediction of satellites' orbits	**7-8**
• Outlines Kepler's Laws and energy considerations and how these relate to a satellite's orbit	**5-6**
• Outlines some quantitative or explicit information about satellite orbits	**3-4**
• Provides some relevant information	**1-2**

Kepler's Laws of planetary motion state that a satellite's orbit is elliptical and that its orbit will sweep out equal area in equal time. Kepler's Third Law, that the radius cubed divided by the period squared is a constant for the same central orbited body (in the case of GPS, the Earth) shows that these laws relate to energy considerations. If a satellite loses gravitational potential energy (U) by falling closer to the orbited body, r, the radius, decreases and this lost energy is converted into kinetic energy (speed) of the satellite. This is why Kepler's 2nd Law (the Law of equal areas) holds and happens for every orbit that is not perfectly circular. For a given satellite, U+K = constant, so that $-\frac{GMm}{r} + \frac{1}{2}mv^2 = \text{constant}$. Using these relationships and by observing a satellite's orbital eccentricity (or path) allows for accurate predictions of the exact position of the satellite at any time in the future, assuming that the satellite is higher than the outer limits of the atmosphere so that no friction effects are encountered.

25.a.

Marking Criteria	Marks
• Correct answer supplied	**2**
• A relevant step in the calculation is made correctly	**1**

$$W = qV$$
$$\frac{1}{2}mv^2 = qV$$
$$v = \sqrt{\frac{2qV}{m}}$$
$$= \sqrt{\frac{2\times1.6\times10^{-19}\times2\times10^{3}}{1.673\times10^{-27}}}$$
$$= 6.18\times10^{5}\ \text{m s}^{-1}$$

25.b.

Marking Criteria	Marks
• Complete and correct explanation given	**2**
• Incomplete and/or partially correct explanation given	**1**

The work done, W, on the proton is transformed into the proton's kinetic energy. Since this value is determined by qV, i.e. the charge of the proton (constant) multiplied by the potential difference between the two plates (not dependent on the distance between the plates), there is no relationship between the proton's speed and the distance between the plates.

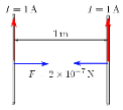
26.

Marking Criteria	Marks
• Multiple sources of energy loss identified and associated design features discussed thoroughly • Physics principles underlying transformers are clearly referenced and described	**5**
• Multiple sources of energy loss identifies and associated design features outlined • Physics principles referenced	**4**
• At least one source of energy loss identified and an associated design feature outlined • At least one physics principle identified	**3**
• several aspects of transformer design, efficiency or principles outlined	**2**
• An aspect of transformer efficiency or principles is identified	**1**

Transformers operate by linking the changing flux generated by a primary coil which is connected to an AC power source to a secondary coil. The changing flux through this secondary coil induces and EMF - $EMF = -n\frac{d\Phi}{dt}$ in the turns of the coil, and a secondary current results if a circuit exists. The resistance in the wires of the coils may cause ohmic heating, a source of inefficiency, so wire with appropriate cross-sectional area is used, especially for the secondary coil in step-down transformers where the current increases, as P=VI and ideally $P_{in} = P_{out}$ for a 100% efficient transformer. A soft iron core is used to link the two coils to maximise flux linkage, yet some of this flux is lost, known as "flux leakage". However, eddy currents are induced in this core which, when flowing, generate heat and thus decrease the efficiency of the transformer. To minimise the eddy currents, the core is laminated with thin insulating material between each layer. In these ways, the efficiency of a transformer is maximised.

27.

Marking Criteria	Marks
• Thorough discussion includes the definition of the ampere • Newton's Third Law stated and related to definition	**4**
• Definition of ampere given AND • Newton's Third Law described	**3**
• Definition of ampere given OR • Newton's Third Law described	**2**
• An aspect of either the ampere, its definition or Newton's 3rd Law is supplied	**1**



Newton's Third Law states that for every force (or action) there is an equal and opposite force (reaction). Pre May 2019, the definition of the ampere is the electric current in two infinitely long parallel wires of negligible cross section one metre apart that produces a force between the wires of exactly 2 x 10^{-7} N. This definition relates to Newton's Third Law in that the force on one of the wires is equal and opposite to the force on the other wire – whether the force is attractive or repulsive is not relevant.

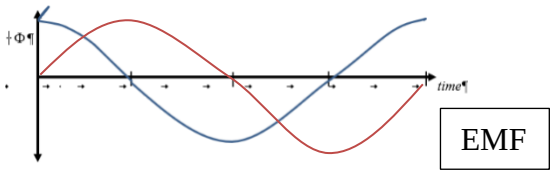
28.

Marking Criteria	Marks
• The principles of magnetic braking are described thoroughly • Response clearly explains how the conservation of energy applies	**4**
• The principles of magnetic braking are described • Response explains how the conservation of energy applies	**3**
• Magnetic braking operation is outlined	**2**
• A relevant aspect of the operation of magnetic braking is identified OR • an overview of how energy conservation applies is outlined	**1**

Magnetic braking utilises a strong source of a magnetic field (i.e. electromagnets) to induce eddy currents. One application is the electromagnets being placed either side of a spinning metal disc. The disc is a part of a rotating axle on a vehicle such as a train or car. As an area of the disc comes towards the electromagnets, induced eddy currents due to the increasing flux through the disc flow in such a direction such that the magnetic field they generate opposes the magnetic field from the electromagnets. As the same area of the disc moves away from the electromagnets, the eddy currents reverse and the magnetic fields attract. In both ways, the force on the disc opposes its rotation. Complying with the conservation of energy, the eddy currents produce heat due to ohmic heating in the disc. This ohmic heating comes from a loss of kinetic energy from the wheels. This heat can be dissipated more easily than in friction brakes as there is nothing in physical contact with the disc to hinder this.

29.a.

Marking Criteria	Marks
• Correct shape and correct orientation/sign, drawn and labelled	**2**
• Correct shape drawn	**1**



29.b.

Marking Criteria	Marks
• One appropriate and correct way described	**1**

1. The graph's amplitude, or peak EMF, would increase, OR
2. The frequency of the graph would increase (or the period decrease)

30.

Marking Criteria	Marks
• The production of a star's absorption spectrum is described thoroughly with detail and clarity • All features of a star are related to characteristics of its spectrum thoroughly with detail and clarity	**9**
• The production of a star's absorption spectrum is described thoroughly with detail • All features of a star are related to characteristics of its spectrum thoroughly	**7-8**
• The production of a star's absorption spectrum is described • Most features of a star are related to its spectrum	**5-6**
• The production of a star's absorption spectrum is outlined	**3-4**
• Several relevant aspects of the question are outlined	**2**
• One relevant aspect of the question is outlined	**1**

The absorption spectrum of a typical star is produced by elements in the atmosphere of the star absorbing only certain wavelengths of the continuous spectrum being produced from the star's core. According to E=hf, the characteristic wavelengths absorbed by a particular element represent the electron energy level transitions when an electron absorbs a photon of light and jumps up to a higher allowed energy level. When the electron falls back to its original energy level the photon of light it re-emits can be in any direction, so that the intensity of the original light is diminished and appears as an absorption line in the spectrum. The star's surface temperature can be found using either Wien's Law: $\lambda_{\max} = \frac{b}{T}$, i.e. the peak intensity wavelength gives the surface temperature, or by classifying the star's spectral class using relative intensities of certain absorption lines. The rotational velocity of the star is found by analysing the spread of the spectral lines as one side of the rotating star is moving towards the observer while the other side is receding, the spectral line displays both red and blue shifting simultaneously.
The translational velocity is determined by the overall red or blue shift of the entire spectrum due to the star either moving towards (blue shift) or away from (red shift) the observer. The star's density, or luminosity class, is found from analysis of the definition of the spectral lines. Highly defined lines are produced from low pressure gases found in giant stars' atmospheres. Thicker lines are produced in higher density gases found in more compact, main sequence stars and more so in white dwarf stars. The chemical composition of a star is found by observing the relative intensities of absorption lines which are characteristic of individual elements, like fingerprints that identify an element.

31.

Marking Criteria	Marks
• An appropriate procedure is outlined clearly and fully • How Malus's Law is verified is clearly apparent • Relevant diagrams used are clear and supportive	**5**
• An appropriate procedure is outlined clearly • How Malus's Law is verified is apparent • Relevant diagrams used are supportive	**4**
• An appropriate procedure is outlined • How Malus's Law is verified is apparent • Relevant diagrams are used	**3**
• A relevant procedure is identified with some omissions	**2**
• Several relevant steps are outlined	**1**

Malus's Law states that the intensity of polarised light, I_o, after it has passed through another polarising filter where the angles between the two polarisers is θ becomes $I = I_o \cos^2 \theta$. A procedure that verifies this relationship is:

1. Obtain a source of polarised light – e.g. a laptop screen with a blank, white page.
2. Use a piece of polarised material and check the orientation of the source light so that maximum light passes through.
3. Using sticky tape, attach the polarising material so that it covers the light sensor on the front of a smartphone.

4. Install Physics Toolbox Suite (or similar) that can record the inclination of the phone and the light intensity.
5. Holding the phone at a constant distance from the polarised light source, record the illuminance (light intensity) as the phone's inclination is varied from 0° through to 90° from the polarised light source.
6. Record the results in a table, with 2 extra columns for $\cos\theta$ and then $\cos^2\theta$.
7. Plot the light intensity, I, against the square of $\cos\theta$ (i.e. $\cos^2\theta$). The gradient of the line of best fit is a value of the original light intensity, I_o.
   (Appropriate diagram or sketch of phone with polarised material, laptop and inclination angle θ should be included).

32.

Marking Criteria	Marks
• Correct answer with correct units and significant figures used	**3**
• Correct answer but incorrect sig. figs or incorrect unit used (i.e. J)	**2**
• Correct expression cited	**1**

$$W = qV = hf - \Phi$$

so:

$$qV = hf - \Phi$$

$$(1.6\times10^{-19})\times1.60 = 6.626\times10^{-34}\times6.6\times10^{14} - \Phi$$

$$\Phi = 4.37\times10^{-19} - 2.56\times10^{-19}$$

$$= 1.81\times10^{-19}\ \text{J}$$

$$= \frac{1.81\times10^{-19}}{1.6\times10^{-19}}$$

$$= 1.1\ \text{eV}$$

33.

Marking Criteria	Marks
• Analysis of the role of atomic clocks is clear • A method by which time dilation was verified is described • Time dilation is explained	**3**
• Two aspects of either time dilation or the role of atomic clocks or a verification method is outlined	**2**
• One aspect of either time dilation or the role of atomic clocks or a verification method is outlined	**1**

In 1971, a physicist Joseph Hafele and an astronomer, Richard Keating devised an investigation whereby atomic clocks were flown in commercial aircraft around the world, some from east to west, others west to east. Another set of atomic clocks remained on the ground. Such clocks are accurate to within several billionths of a second. Despite the relatively slow speeds of the aircraft, the clocks flown disagreed with the stationary clocks when they were compared. Taking into account both the more complex general relativity effects and the special relativity effects, the amount of disagreement between the clocks matched that predicted, within experimental error.

34.

Marking Criteria	Marks
• Process is named correctly • All steps involved in the nucleosynthesis of helium outlined clearly and correctly	**4**
• All steps are outlined but with an error or omission	**3**
• Several steps outlined correctly	**2**
• One correct step is shown	**1**

The process is known as the proton-proton chain and occurs in the following steps:

$2\times \quad {}_1^1\mathrm{H}+{}_1^1\mathrm{H} \rightarrow {}_1^2\mathrm{H}+{}_{+1}^0e+\nu$ 2 protons collide and form a deuterium nucleus, a positron and an electron neutrino

$2\times \quad {}_1^2\mathrm{H}+{}_1^1\mathrm{H} \rightarrow {}_2^3\mathrm{He}+\gamma$ a deuterium collides with another proton to form a helium-3 nucleus and a gamma ray is emitted

${}_2^3\mathrm{He}+{}_2^3\mathrm{He} \rightarrow {}_2^4\mathrm{He}+{}_1^1\mathrm{H}+{}_1^1\mathrm{H}$ 2 helium-3 nuclei collide to form a helium-4 and 2 protons

$4{}_1^1\mathrm{H} \rightarrow {}_2^4\mathrm{He}+2\,{}_{+1}^0e+2\nu$ overall

35.a.

Marking Criteria	Marks
• Complete explanation is provided	**2**
• Incomplete or partial explanation provided	**1**

The force on the cathode ray particles is always perpendicular to the velocity of the particle. This force will therefore not change the speed of the particles, only their direction. As the applied force F is proportional to the velocity ($F=qvB\sin\theta$), this constant force, perpendicular to the velocity is, in effect, a centripetal force directed towards the centre of the arc.

35.b.

Marking Criteria	Marks
• Correct answer provided	**2**
• Appropriate calculation attempted OR • the two forces equated with substitution	**1**

$$F_c = F_B$$

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

$$mv = qBr$$

$$v = \frac{qBr}{m}$$

$$= \frac{1.6\times10^{-19}\times5.0\times10^{-3}\times70.0\times10^{-3}}{9.1\times10^{-31}}$$

$$= 6.2\times10^{7}\ \mathrm{m\ s^{-1}}$$

36.

Marking Criteria	Marks
• Appropriate equation used • Realistic example of everyday moving object used to find corresponding wavelength • Resulting wavelength commented upon appropriately	**3**
• Appropriate equation cited • Realistic example of everyday object used • Wavelength commented upon	**2**
• One aspect of the above OR • several aspects of the above partially or incorrectly attempted	**1**

e.g. a tennis ball served at 40 m s^{-1} (possible in higher level tennis) with mass approx. 60 g

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

$$= \frac{6.626\times10^{-34}}{0.060\times40}$$

Use: $= 2.8\times10^{-34}$ m

Clearly, this wavelength, which is shorter than the diameter of a proton by a factor of ~10^{19}, is far too short to be observable.

37.a.

Marking Criteria	Marks
• Correct answer obtained	**2**
• Appropriate formula selected with an error made subsequently	**1**

$$E = mc^2$$

$$m = \frac{E}{c^2}$$

$$= \frac{3.86\times10^{26}}{(3.00\times10^{8})^2}$$

using E = 3.86 x 10^{26} J produced each second: $= 4.29\times10^{9}$ kg each second

37.b.

Marking Criteria	Marks
• Mass deficit per He formed calculated • Answer from Q37a (or estimate) used to find number of He formed per second	**3**
• Mass deficit per He formed calculated with an error • Answer from Q37a (or estimate) used to attempt calculation of number of He formed per second (No penalty if mass of 2 electrons included per He)	**2**
• One aspect of the above	**1**

Given 4 protons at 1.673 x 10^{-27} kg each form 1 He nucleus at 6.648 x 10^{-27} kg each, mass deficit per He formed:
mass deficit = (4 x 1.673 x 10^{-27}) – 6.648 x 10^{-27} = 0.044 x 10^{-27} kg (or 4.4 x 10^{-29} kg)
Number He nuclei per second = 4.29 x 10^{9} kg s^{-1} ÷ 4.4 x 10^{-29} kg per He = 9.75 x 10^{37} He nuclei formed per sec.

38.

Marking Criteria	Marks
• The roles of the four fundamental forces are outlined thoroughly and clearly	**4**
• The roles of 3 of the identified forces outlined clearly • OR • all forces identified and for 3 forces, roles outlined	**3**
• Three of the fundamental forces identified OR • the role of one identified force is outlined	**2**
• A fundamental force is identified	**1**

Gravitational force – acts over large distances between objects with mass, governed by $F = \frac{GMm}{r^2}$

Electromagnetic force – forces between charged particles and between magnets, as well as the force on moving charges within a magnetic field

Strong nuclear force: attractive force between nucleons (protons and neutrons) over very short distances that overcomes the electromagnetic force between protons in nuclei.

Weak nuclear force: the force between nucleons, again acting only over very short distances such as those between these particles, responsible for beta decay.