Freshwater SENIOR CAMPUS

FREEDOM TO LEARN

Student Number

2020

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time- 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams in pencil
- Board approved calculators may be used
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your student number on this page and your Name and number on the Multiple Choice answer sheet

Total marks – 100

Section I

20 marks

- Attempt questions 1-20
- Allow about 40 minutes for this part

Section II

80 marks

- Attempt **ALL** question in this section
- Allow about 2 hours 20 minutes for this section

Section I
20 marks

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

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

1 Which of the following strategies would most improve the efficiency of a step up electrical transformer?

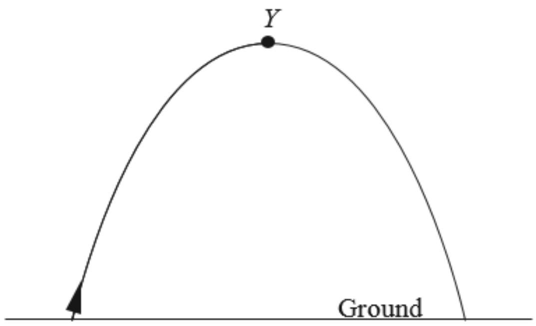
(A) Reduce the induced flux from the primary input coil.

(B) Make the primary input coil out of thick copper wire.

(C) Make the core from enamel paint separated laminated soft iron.

(D) Make the core out of enamel paint separated laminated hard iron.

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 kinetic energy at point Y will be zero.

(B) The potential energy at point Y is a minimum.

(C) The kinetic energy will be the same at launch as at impact.

(D) The kinetic energy on launch will be the same as the potential energy at point Y.

3 The radius of the Earth's orbit around the Sun, assumed circular, is 1.5×10^{8} km, and the Earth travels around this orbit in 365 days.
What is the magnitude of the orbital velocity of the Earth in ms^{-1}?

(A) 298.86 ms^{-1}.

(B) 29886 ms^{-1}.

(C) 29886 kms^{-1}.

(D) 16994 ms^{-1}.

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 is halved?

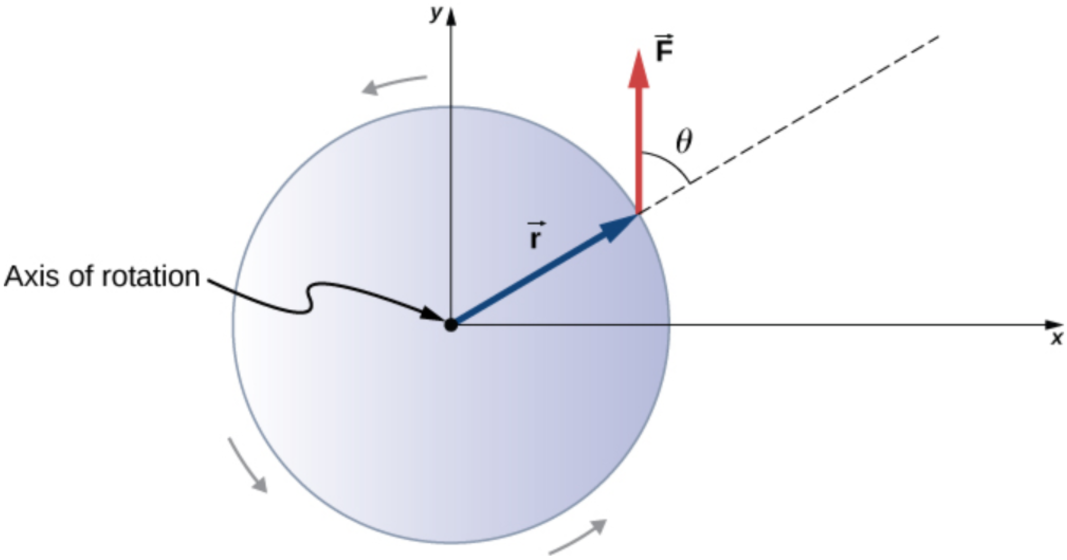
(A) Acceleration is halved.

(B) Acceleration is doubled.

(C) Acceleration remains the same.

(D) Acceleration increases by eight times.

5 The figure below shows a disc of radius 100 cm undergoing rotation about a central axis where it is accelerated by a 100 N force applied at an angle $\Theta = 30\ ^{o}$ at the circumference.



What is the torque value that correctly describes the effect on the turning of the disc?

(A) 50 Nm

(B) 86.6 Nm

(C) 5000 Nm

(D) 8660 Nm

6 Planet X has a radius twice that of Earth. The acceleration due to gravity on the surface of this planet is half that on the surface of Earth.

What is the mass of Planet X?

(A) 5.962×10^{24} kg

(B) 1.193×10^{25} kg

(C) 2.981×10^{21} kg

(D) 3.945×10^{23} kg

7 Two parallel wires separated by a distance of one metre each carry a current of 1 ampere. That is the force per metre length between the wires?

(A) 2×10^{-7} N

(B) 2×10^{-7} Nm^{-1}

(C) 8×10^{-7} Nm^{-1}

(D) $2\pi \times 10^{-7}$ Nm^{-1}

8 The purpose of the commutator in a DC generator is to:

(A) reduce sparking at brushes.

(B) provide smoother output.

(C) increase output voltage.

(D) convert the induced alternating current into direct current.

9 A metal ball bearing on a string is swung around in a horizontal circle of radius 80 cm. A force meter indicates the centripetal force experienced by the ball is 1.9 N. The angular velocity of the motion is $4\pi rads^{-1}$.

What is the mass of the ball?

(A) 0.19 kg

(B) 0.15 kg

(C) 0.019 kg

(D) 0.015 kg

10 Which statement is true about the effect of back emf in a DC motor?

(A) Back emf increases the current flow in a motor.

(B) Back emf increases the supply voltage to a motor.

(C) Back emf increases the mechanical energy produced in the armature.

(D) Back emf decreases the mechanical energy produced in the armature.

11 A ball of 600 grams is kicked at an angle of 35° with the ground with an initial velocity V_0. What is the initial velocity V_0 of the ball if its kinetic energy is 22 J when its height is maximum?

(A) 8.563 ms^{-1}

(B) 10.45 ms^{-1}

(C) 12.30 ms^{-1}

(D) 15.28 ms^{-1}

12 The Large Hadron Collider can cause protons to reach a relativistic speed of 0.9999991c. Determine the momentum of a proton travelling at this speed.

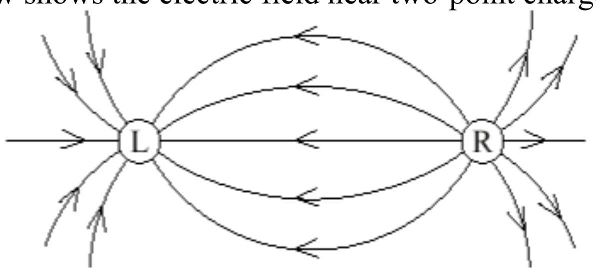
(A) 3.741×10^{-16} Ns

(B) 1.871×10^{-16} Ns

(C) 1.247×10^{-24} Ns

(D) 1.247×10^{-24} kg

13 The diagram below shows the electric field near two-point charges L and R.



What is the polarity of each charge?

(A) Both are positive

(B) Both are negative

(C) L is negative, R is positive

(D) L is positive, R is negative

14 Monochromatic light of wavelength 589 nm from a coherent light source is incident on two slits. The distance between the slits is 2.4×10^{-4} m. An interference pattern is observed on a screen. The slit-to-screen distance is 0.75 m. The distance between adjacent maxima on the screen is closest to:

(A) 1.84 mm

(B) 1.84 cm

(C) 0.184 mm

(D) 0.000184 m

15 When a charge is accelerated through a potential difference of 500 V, its kinetic energy increases from 2.0×10^{-5} J to 6.0×10^{-5} J. What is the magnitude of the accelerated charge?

(A) 4.0×10^{-8} C

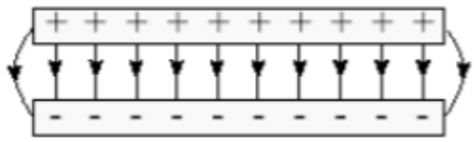
(B) 8.0×10^{-8} C

(C) 1.2×10^{-7} C

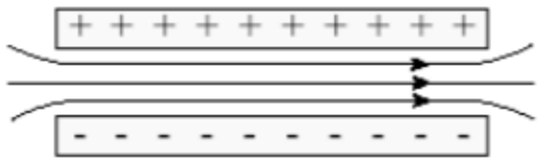
(D) 1.6×10^{-7} C

16 Which diagram shows the electric field between a pair of charged parallel plates?

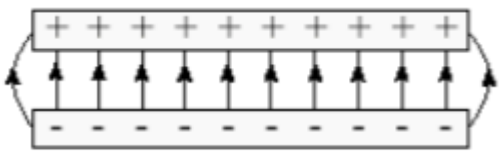
(A)



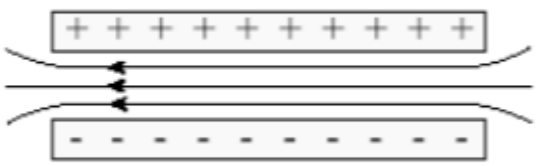
(B)



(C)



(D)



17 In 2012 scientists at the European Organisation for Nuclear Research (CERN) in Switzerland claimed to have found the Higgs boson. They measured its rest energy as 126 GeV. If this measurement is correct, the mass of the Higgs boson is closest to:

(A) 1.40×10^{-9} kg.

(B) 2.24×10^{-24} kg.

(C) 2.24×10^{-25} kg.

(D) 1.40×10^{-24} kg.

18 A conductor of length 12.0 cm carries a current of 40 mA in a magnetic field of strength 0.50 T and makes an angle of 45^0 with the field. The force experienced on the conductor is:

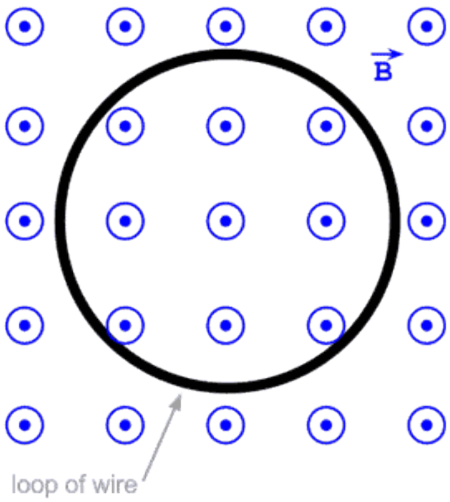
(A) 1.7 N

(B) 2.4 N

(C) 1.7×10^{-3} N

(D) 2.4×10^{-3} N

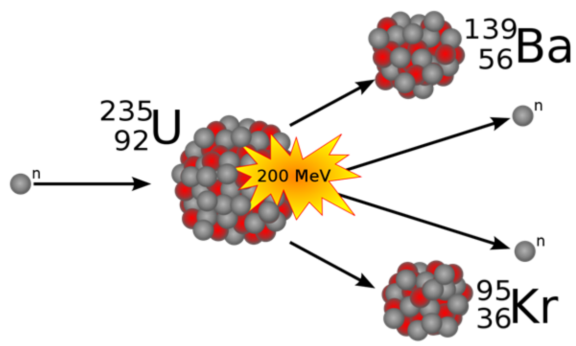
19 Calculate the magnetic flux of the situation in the diagram below if the radius of the circle is 8 cm:



B = 2 T

(A) 0.02 Wb
(B) 0.04 Wb
(C) 0.5 Wb
(D) 200 Wb

20 Identify the type of nuclear reaction shown in the diagram below.



(A) Beta Decay

(B) Alpha Decay

(C) Fusion Reaction

(D) Fission Reaction

Section II - 80 marks
Attempt Questions 21-36
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 24 and 25. If you use this space, clearly indicate which question you are answering.

Question 21 (3 marks)

At time t = 0, a motorcycle wheel of radius 0.3 m has an initial angular velocity of 25.0 rads^{-1}. It has a constant angular velocity until a brake is applied at time t = 2.00 s. From then on, the wheel turns through an angle of 440 rad as it slows to a stop at constant angular deceleration. Calculate the total distance travelled using s=rω **2**

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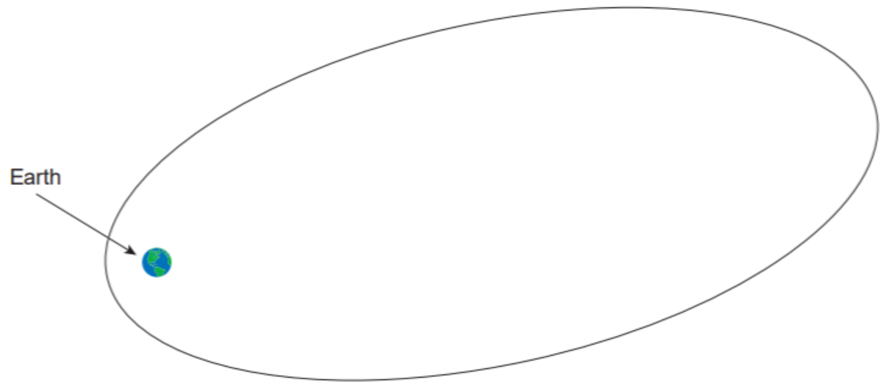
Question 22 (3 marks)

In 2018 a satellite named Transiting Exoplanet Survey Satellite (TESS) was launched. The satellite travels in an elliptical orbit around the Earth. The diagram below shows an elliptical orbit.



Explain why energy is conserved in an elliptical orbit. **2**

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Question 23 (3 marks)

The International Space Station (ISS) orbits at 4.00 $\times 10^2$ km above Earth's surface in a circular orbit. Using the Potential Energy formula calculate the minimum energy required to lift a 9000 kg Soyuz space capsule to the docking orbit of the ISS. **3**

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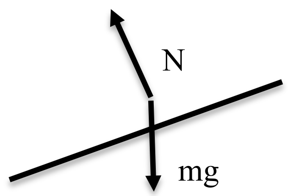
Question 24 (3 marks)

A curve of radius 70m is banked at a 15° angle. Calculate the speed that a car can take this curve without assistance from friction? **3**



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Question 25 (5 marks)

An iron-56 atom is found experimentally to have a mass of 9.3634×10^{-26} kg.

(a) Calculate the theoretical mass of an iron-56 atom. **1**

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(b) Calculate the mass defect of the iron-56 atom. **2**

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(c) Calculate the binding energy of the iron-56 atom. **2**

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Question 26 (5 marks)

A proton entered a uniform magnetic field that had a magnitude of 0.80 T. The initial velocity of the proton was 3.3×10^{6} m s^{-1} perpendicular to the magnetic field.

(a) Explain why the proton travelled in a circular path at a constant speed after entering the magnetic field. **2**

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(b) Determine the radius of the circular path taken by the proton. **3**

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Question 27 (5 marks)

As part of a depth study investigation of light, a red laser light of wavelength 650 nm is used as a monochromatic source which is aimed at a double slit engraved into a blackened slide. The interference pattern it produces is observed on a screen at a distance of 100 cm from the slits.

(a) Outline the risk assessment the student would need to complete before commencing the investigation.. **3**

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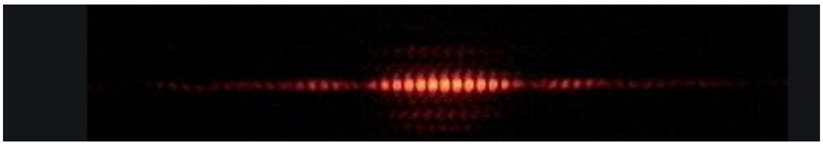
(b) With the aid of a diagram explain how the interference of the red laser light waves from a double slit would produce the image below that the student saw on the screen. **2**



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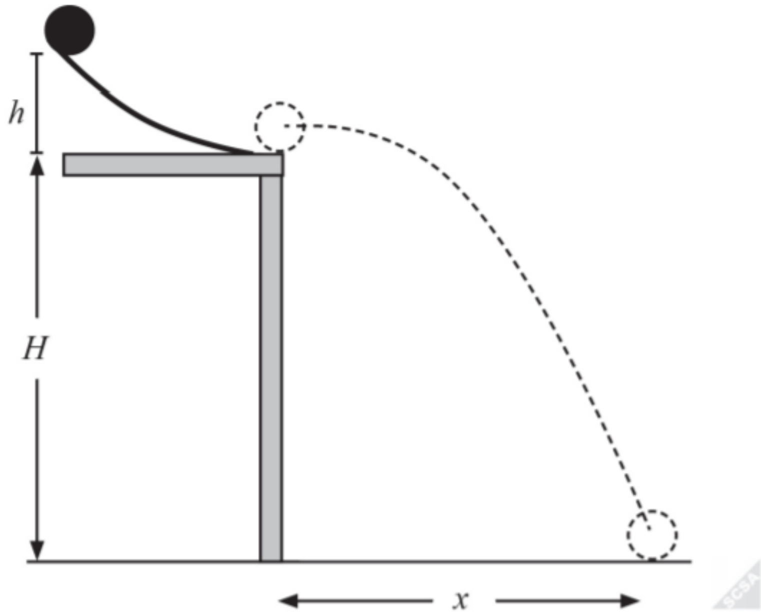
Question 28 (5 marks)

A ball is rolled from rest down a curved slope, across a flat, smooth table leaving the table horizontally and falling to the floor.



(a) If h = 60 cm, determine the initial velocity of the ball as it leaves the table. **1**

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(b) If H = 1.2 m determine the velocity of the ball immediately before impacting the ground. **2**

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(c) Determine the range x. **2**

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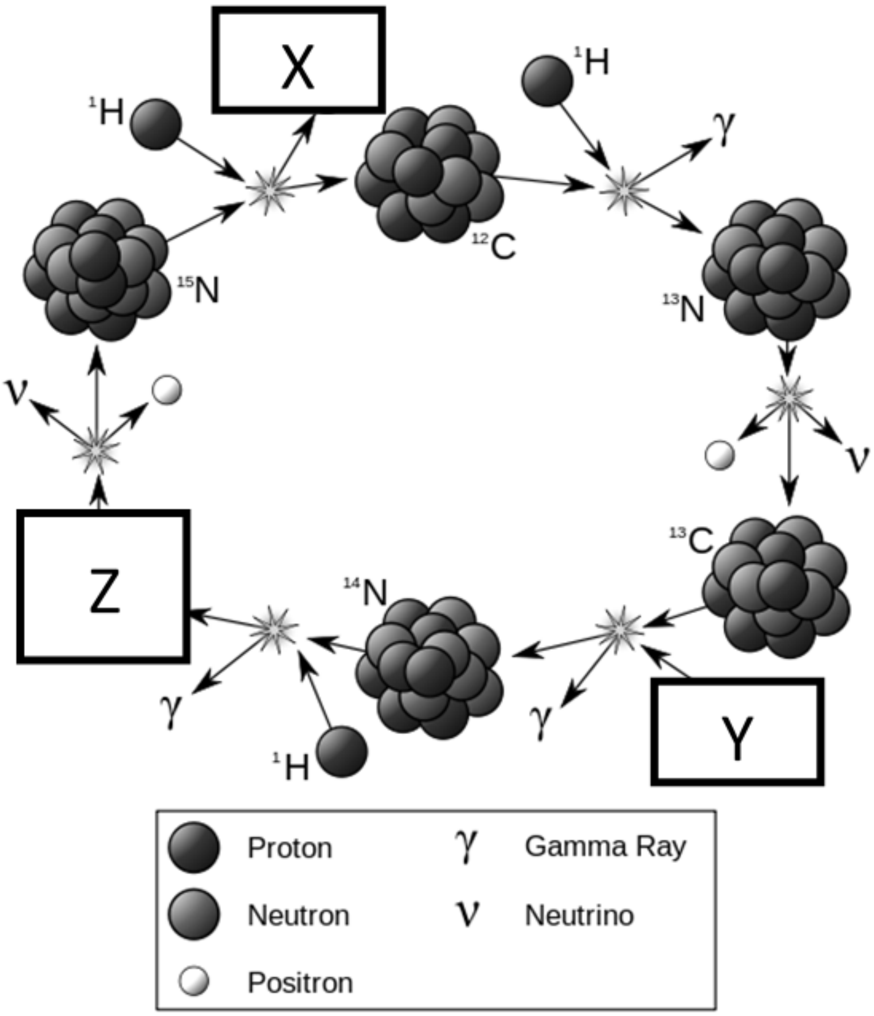
Question 29 (5 marks)

Below is a diagram of the CNO (Carbon-Nitrogen-Oxygen) cycle. **3**



(a) Write the full name OR annotated symbol of the missing isotopes from each box: 3

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(b) Given the values below, calculate the energy of the gamma ray "γ" emitted by the fusion of a Carbon-12 with a Hydrogen-1 to produce a Nitrogen-13 atom. **2** 3

Particle	Mass (amu)
Carbon-12	12.010
Hydrogen-1	1.008
Nitrogen-13	13.006

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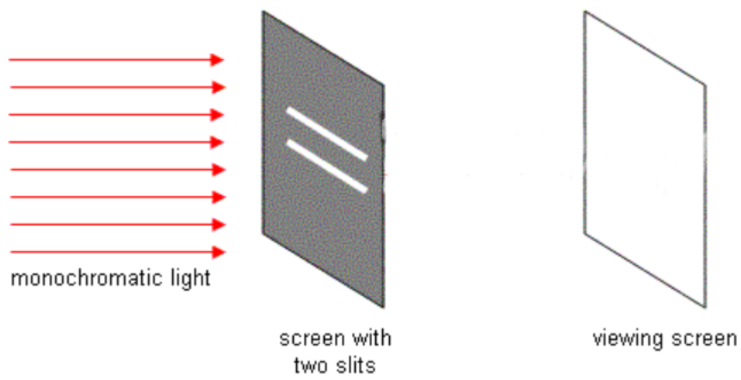
Question 30 (5 marks)

One of the most famous experiments that supported a model of light was Young's double slit experiment. This experiment enables the observation of one of light's properties.

(a) Describe the results Young would have expected if light had a particle nature using a diagram on the viewing screen to aid your description. **1**



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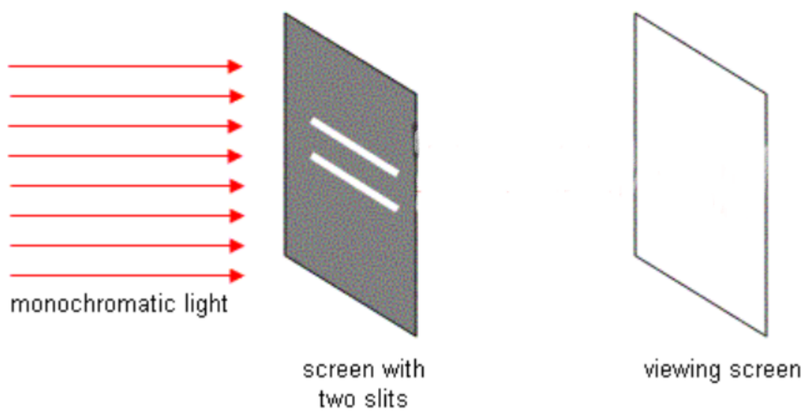
(b) Describe the results Young would have expected if light had a wave nature using a diagram on the viewing screen to aid your description. **1**



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(c) Describe why these results Young obtained provided evidence that light had a wave nature. **3**

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Question 31 (5 marks)

The Hafele-Keating experiment provided validation of Einstein's thought experiment on time dilation. Describe the main features of this experimental method that ensured it was performed reliably, accurately and validly. **5**

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Question 32 (5 marks)

A distant star has a planet orbiting in perfectly circular path. The period of the planet's orbit is 50 Earth days. The radius of the planet's orbit is measured to be 7.0×10^{10} m.

(a) Calculate the mass of the star. **3**

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(b) Explain why it is not possible to calculate the mass of the planet if using only this data. **2**

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Question 33 (6 marks)

(a) The photoelectric effect was a phenomenon that could not be explained by classical wave physics. Describe three features that could not be explained if light had a classical wave nature. **3**

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(b) How did Einstein explain the photoelectric effect? Support your answer with relevant equations. **3**

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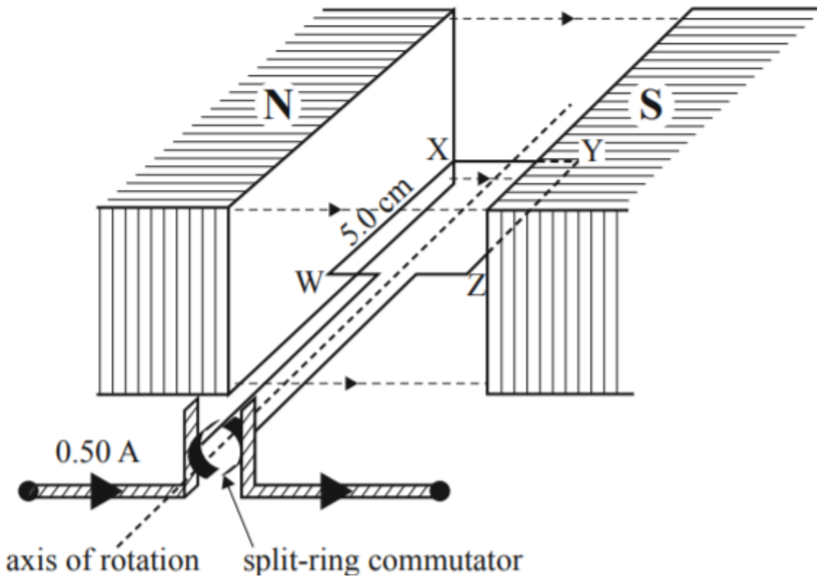
Question 34 (6 marks)

A model representing a motor is shown below.



(a) What type of motor is it? **1**

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(b) Compare the physical principles of operation of this motor and its components with a generator. **2**

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(c) While in the position shown in the diagram, a current of 0.50 A is flowing in the rotating coil. The coil has 10 turns and the magnetic field across the coil has a strength of 1T. The side WX of the rectangular coils has a length of 5.0 cm and the side XY is 3 cm. Calculate the magnitude of the maximum torque on the coil and the direction of its rotation. **3**

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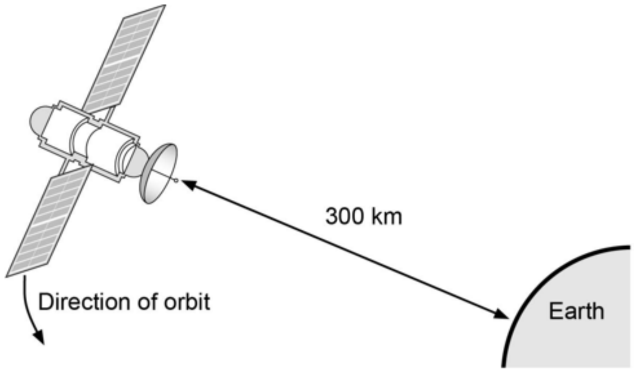
Question 35 (7 marks)

A 100 kg satellite is placed into an elliptical low Earth orbit with an average altitude of 300 km.



(a) Calculate the predicted period of the satellite. **3**

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(b) Determine the total energy of the satellite. **2**

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(c) Calculate the average orbital speed of the satellite in orbit. **2**

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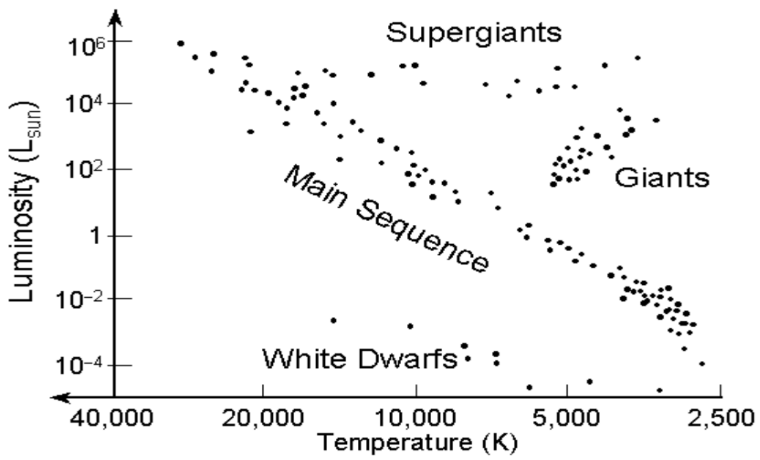
Question 36 (9 marks)



The diagram above represents a version of the Hertzsprung- Russell diagram.

(a) Describe how the Hertzsprung-Russell diagram can be used to determine the characteristics and evolutionary stage of a star. **3**

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(b) Outline how the Hertzsprung-Russell diagram can be used to identify the classification of the star. **2**

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(c) Most stars plot along the Main Sequence in the Hertzsprung-Russell diagram. Outline what the position of a star in the main sequence means for predicting the life cycle of most stars. **2**

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(d) Stars on the main sequence such as our Sun produce energy predominantly by the proton - proton chain. Outline what is meant by the proton - proton chain. **2**

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Section II extra writing space
If you use this space, clearly indicate which question you are answering.

FREEDOM TO LEARN

Freshwater
SENIOR CAMPUS

2020

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

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Student Name

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Class

Physics Multiple Choice

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
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	17	A	B	C	D
	18	A	B	C	D
	19	A	B	C	D
	20	A	B	C	D

2020 Higher School Certificate
Trial Examination
Physics
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21

Criteria	Marks
• A correct calculation of the total distance travelled including correct units	2
• A correct calculation of the total distance travelled or a partially correct calculation of part of the distance travelled including correct units	1

Sample answer

$$s = r\theta = 0.3 \times ((2 \times 25) + 440) = 147\ m$$

Question 22

Criteria	Marks
• Applies a thorough understanding of the behaviour of a satellite in an elliptical orbit recognising and describing that there is no external force applied to the satellite and that the law of conservation of energy applies to the satellite motion	2
• Applies an understanding that the motion of a satellite in an elliptical orbit is an application of the law of conservation of energy	1

Sample answer

For a satellite the sum of the initial kinetic and potential energy plus any external work done on the satellite will equal its final kinetic and potential energy. This can be expressed as

$$KE_i + PE_i + Wext = KE_f + PE_f$$

The W_{ext} term in this equation is representative of the amount of work done by external forces and for the satellite, the only force is gravity. Since gravity is an internal force, the W_{ext} term is zero. The equation can then be simplified to the following form.

$$KE_i + PE_i = KE_f + PE_f$$

Thus the total mechanical energy of the system is conserved. That is, the sum of kinetic and potential energies is unchanging. So while energy can be transformed from kinetic energy into potential energy, and vice versa, the total amount of energy remains the same meaning an increase in KE leads to a decrease in PE or a decrease in KE leads to an increase in PE and that is happening constantly in an elliptical orbit.

Question 23

Criteria	Marks
• A correct response showing all calculations	2
• An incorrect calculation with one substitution error	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

$radius\ of\ the\ Earth\ +\ 4.00\ \times\ 10^2\ km\ =\ 6.371 \times 10^6 + 400000 = 6\,771\,000\ m$

The minimum energy required to lift the 900kg Soyuz space craft to the ISS is equal to the $\Delta PE = PE_f - PE_i$

$$PE_f = \frac{-GM_{earth}m_{Soyuz}}{r^2}$$

$$PE_f = \frac{-6.67 \times 10^{-11} \times 6 \times 10^{24} \times 9000}{6771000}$$

$$PE_f = 5.32 \times 10^{11}\,J$$

$$PE_i = \frac{-GM_{earth}m_{Soyuz}}{{r_{Earth}}^2}$$

$$PE_i = \frac{-6.67 \times 10^{-11} \times 6 \times 10^{24} \times 9000}{6.371 \times 10^6}$$

$$PE_i = 5.65 \times 10^{11}\,J$$

$\Delta PE = PE_f - PE_i = 3.34 \times 10^{10}\,J$

Question 24

Criteria	Marks
• A correct calculation of the maximum velocity that the car can navigate the curve ignoring all other forces	3
• A correct calculation of the maximum velocity with incomplete working shown or lacking units	2
• An incorrect calculation of the maximum velocity with incorrect substitution	1

Sample answer

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

$$v = \sqrt{gr\ tan\theta}$$

$$v = \sqrt{9.8 \times 70 \times tan\ 15^\circ}$$

$$v = 13.56\,ms^{-1}$$

Question 25

25(a)

Criteria	Mark
• A correct calculation of the theoretical mass of an iron-56 atom	1

Sample answer

An iron-56 atom has 26 protons, 26 electrons and 30 neutrons.

Therefore

$$m = (26 \times 1.673 \times 10^{-27}) + (26 \times 9.109 \times 10^{-31}) + (30 \times 1.675 \times 10^{-27})\ kg$$

$$m = 9.377 \times 10^{-26} kg$$

25(b)

Criteria	Marks
• A correct calculation of the mass defect	2
• A correct calculation method with an incorrect substitution	1

Sample answer

$$Mass\ defect = theoretical\ mass - experimental\ mass$$

$$Mass\ defect = 9.3772 \times 10^{-26} kg - 9.3634 \times 10^{-26}\ kg$$

$$Mass\ defect = 1.3768 \times 10^{-28} kg$$

25(c)

Criteria	Marks
• A correct calculation of the binding energy	2
• A correct calculation method with an incorrect substitution	1

Sample answer

$E = mc^2$
$E = 1.3768 \times 10^{-28} \times (9 \times 10^{16})$
$E = 1.329 \times 10^{-11}$ J

Question 26

26(a)

Criteria	Marks
• Explains that the force exerted on the proton is always perpendicular to its velocity producing a centripetal acceleration with a constant rate of change in velocity directed to the centre of motion because the magnetic field is constant	2
• Applies a good understanding of the behaviour of the proton in a constant magnetic field to explain the resultant motion of the proton is circular with a constant rate of change in velocity directed to the centre of motion	1

Sample answer

Since the movement of the proton is always perpendicular to the force produced by the constant magnetic field on the proton, magnetic forces do no work and the particle's velocity stays constant. Since the force is F = qvB in a constant magnetic field, a charged particle feels a force of constant magnitude always directed perpendicular to its motion. That results in the proton undergoing a circular motion.

26(b)

Criteria	Marks
• A correct response showing all calculations	3
• An incorrect response with one incorrect substitution	2
• A response that equates the centripetal and magnetic forces	1

Sample answer

Since the movement of the proton is always perpendicular to the force produced by the constant magnetic field on the proton, magnetic forces do no work and the particle's velocity stays constant.
The magnetic force is F = qvB in a constant magnetic field,
The centripetal force is produced by that magnetic force. $F = \frac{mv^2}{r}$
Equating the two forces

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

$$r = \frac{1.673 \times 10^{-27} \times 3.3 \times 10^6}{1.602 \times 10^{-19} \times 0.8}$$

$$r = 4.31 \times 10^{-2} m$$

Question 27

27(a)

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

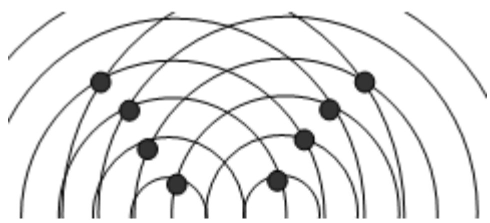
The investigation was conducted in a darkened room, so care was taken not to avoid trip hazards in the dark. We used a low power laser (<1 milliwatt) as the light source as high-power lasers could result in hazards such as burning. Care was taken to avoid the beam entering anyones' eyes including those 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.

27(b)

Criteria	Marks
• A correct detailed response supported by a diagram showing constructive interference of two wave fronts to produce maxima on the screen	2
• A correct response lacking complete detail or a correct supporting diagram	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. The striped pattern of bright lines represents those maxima where waves superimpose constructively as represented by the heavy dots on the figure below.



Question 28
28 (a)

Criteria	Mark
• Equates the potential energy of the ball above the table to the kinetic energy of the ball leaving the table and calculates a correct response including direction	1

Sample answer

Initial velocity as the ball leaves the table is produced by the conversion of potential energy into kinetic energy.

$$PE = KE$$

$$mgh = \frac{1}{2}mv^2$$
$$gh = \frac{1}{2}v^2$$
$$v = \sqrt{2gh}$$
$$v = \sqrt{2 \times 9.8 \times 0.6}$$
$$v = 3.43.ms^{-1}\ in\ a\ horizontal\ direction\ away\ from\ the\ table\ to\ the\ right$$

28 (b)

Criteria	Marks
• A correct determination of the final velocity of the ball just before impact	2
• An incorrect determination of final velocity with one substitution error	1

Sample answer

No component of force is acting on the horizontal velocity of the ball, so it remains a constant 3.43ms^{-1}

The vertical component of velocity is imparted by gravity acting on the falling ball.

$$v^2 - u^2 = 2as$$

$$v^2 - 0^2 = 2 \times 9.8 \times 1.2$$
$$v = \sqrt{23.52}$$
$$v = 4.85\ ms^{-1}$$

using trigonometry
$$v^2 = (3.43 \times 3.43) + (4.85\ \times 4.85)$$
$$v = 5.94\ ms^{-1}$$
the final velocity just before collision is 5.94 ms^{-1} at an angle of 54.7°

28 (c)

Criteria	Marks
● A correct determination of the range of the ball at impact	2
● An incorrect determination of range of the ball with one substitution error	1

Sample answer

The range is equal to the time of flight multiplied by the horizontal velocity. The time of flight is the time for the ball to fall to the ground under the influence of gravity.

$$t = \frac{v - u}{a}$$
$$t = \frac{4.85 - 0}{9.8}$$
$$t = 0.495s$$

range is the product of the horizontal velocity and time of flight.

$$s = v \times t$$
$$s = 3.43 \times 0.495 = 1.7\ m$$

Question 29

a) (3 marks)

Criteria	Marks
· Correctly identifies all of the isotopes.	3
· Correctly identifies some of the isotopes OR · Correctly identifies all of the atoms but does not include the mass numbers.	2
· Correctly identifies some of the atoms but does not include the mass numbers.	1

Sample Answer

X: Helium-4 (^{4}He)

Y: Hydrogen-1 (^{1}H)

Z: Oxygen-15 (^{15}O)

Q29 b) (2 marks)

Criteria	Marks
· Correctly calculates the energy of the gamma ray.	2
· Provides some relevant steps.	1

Sample Answer

Total mass of Reactants = 12.01 + 1.008

= 13.018 amu

Mass defect = Mass Products – Mass of Reactants

= 13.006 – 13.018

= -0.012 amu

Mass defect in Kg = -0.012 x 1.66 x 10^{-27}

= -1.99 x 10^{-29} ***Kg***

Energy (J) = mc^2

= -1.99 x 10^{-29} ***x (3 x*** $10^{8})^2$

= -1.79 x 10^{-12} ***J***

Energy (eV) = -1.79 x 10^{-12} ***x 6.242 x*** 10^{18}

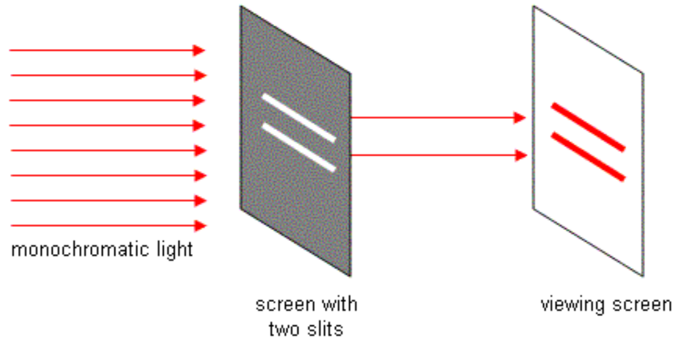
= -11200000 eV

Energy (MeV) = 11.2 MeV released from reaction as a Gamma Ray.

Question 30
30 (a)

Criteria	Mark
• A correct representation drawn on the viewing screen of the diagram	1

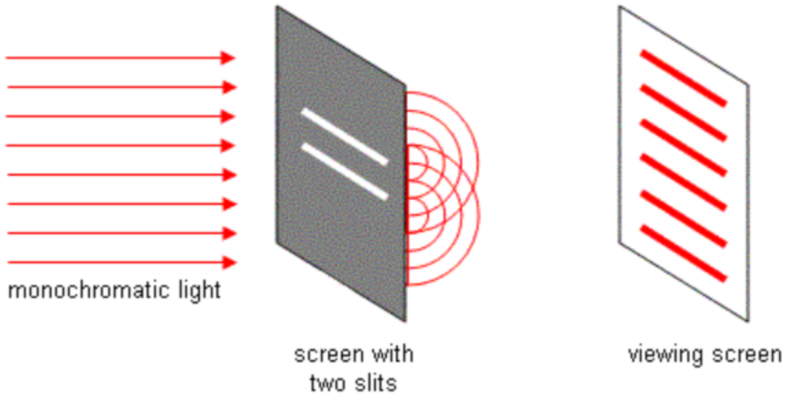
Sample answer



30 (b)

Criteria	Mark
• A correct representation drawn on the viewing screen of the diagram.	1

Sample answer



30 (c)

Criteria	Marks
• Demonstrates an extensive knowledge of the wave theory implications of Young's double slit experiment and identifies that the results of the Young's double slit experiment are not consistent with light being of a particle nature	3
• Demonstrates a knowledge of the wave theory implications of Young's double slit experiment and identifies that the results of the Young's double slit experiment are not consistent with light being of a particle nature	2
• Demonstrates a knowledge of the wave theory implications of Young's double slit experiment	1

Sample answer

The double-slit experiment is a demonstration that light can display characteristics of classically defined waves. The experiment is a "double path" experiment, in which a wave is split into two separate waves that later combine into a single wave. Changes in the path lengths of both waves result in a phase shift, creating an interference pattern. The wave nature of light causes the light waves passing through the two slits to interfere, producing bright and dark bands on the screen – a result that would not be expected if light consisted of classical particles.

Question 31

Criteria	Marks
• A thorough description of the Hafele- Keating experiment and its attention to validity, reliability and accuracy	5
• A thorough description of the Hafele-Keating experiment without a thorough description of its attention to validity or reliability or accuracy	4
• A thorough description of the Hafele-Keating experiment without a thorough description of its attention to two of validity or reliability or accuracy	3
• A description of the Hafele-Keating experiment without a thorough description of its attention to validity or reliability or accuracy	2
• A description of most of the features of the Hafele-Keating experiment	1

Sample answer

To secure highly precise measurements, Hafele and Keating used 6 caesium atomic clocks. They flew four cesium clocks with two aboard a pair of commercial jets. Two clocks in all scenarios provided a check for reliability. One flight went eastward, the other westward. Each flight was over 40 hours of flight. Both were compared to a pair of reference atomic clocks at a Naval Observatory on the ground. Relative to an imagined master clock that is "stationary," the clock flying eastward, in the direction of the Earth's rotation, would be traveling more quickly than the ground clocks, which would be moving with the rotation but otherwise stationary. The planes flying westward would be moving more slowly than the clock on the ground. If special relativity was correct, the eastward flying clock should tick more slowly than the clock on the ground while the westbound clock flying against the Earth’s rotation would be travelling more slowly than the clock on the ground.

Hafele and Keating had worked out exactly how the effects of special relativity should be seen in both the east- and west-flying clocks. Their findings validated Einstein’s special relativity predictions almost exactly. According to their predictive calculations using special relativity the flying clocks should have lost about 40 nanoseconds on the eastern flight compared to the ground clock and gained about 275 nanoseconds on the western flight. They measured a loss of about 59 nanoseconds on the eastward flight and gained around 273 nanoseconds on the westward flight. Both measurements were well within expected error.

Question 32
32 (a)

Criteria	Marks
• A correct calculation of the mass	3
• An incorrect calculation with one substitution error that equates the force of gravitational attraction and Kepler's Laws of planetary motion	2
• Equates the gravitational attraction and Kepler's Laws of planetary motion	1

Sample answer

$$r^3/T^2 = \mathrm{GM}/4\pi^2$$

$$M = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 \times (7.0 \times 10^{10})^3}{6.67 \times 10^{-11} \times (50 \times 24 \times 60 \times 60)^2}$$
$$M = 1.1 \times 10^{31}\ kg$$

32 (b)

Criteria	Marks
• Demonstrates well developed explanation of the relationship between the force of gravitational attraction and Kepler's Laws of planetary motion including that the mass of the planet cancels from both sides of the equation	2
• Demonstrates a knowledge of the relationship between the force of gravitational attraction and Kepler's Laws of planetary motion including that the mass of the planet is a common factor to both	1

Sample answer

Equating centripetal force with gravitational force leads to the equation below. It was not possible to determine the mass of the planet, m, from the data provided because its mass appears on both sides of the equation

$$\frac{GMm}{r^2} = \frac{4\pi^2 rm}{T^2}$$

and thus, cancels out of the equation.

Question 33
33 (a)

Criteria	Marks
● Describes fully three features of the photoelectric effect that could not be adequately explained by classical physics	3
● Describes fully two features of the photoelectric effect that could not be adequately explained by classical physics	2
● Describes fully one features of the photoelectric effect that could not be adequately explained by classical physics	1

Sample answer

1. No photoelectric effect is observed for a particular metal until the incident light is above a threshold frequency no matter the intensity of the light.
2. Above that threshold frequency electrons are immediately released from the metal.
3. The kinetic energy of the released electrons is dependent upon the type of metal surface and the frequency of light incident on the surface.

33 (b)

Criteria	Marks
● Explains Einstein's model of the photoelectric effect fully, relating it to the conservation of energy, photons of energy dependent on their frequency and the concept of the work function using relevant equations	3
● Explains most features of Einstein's model of the photoelectric effect relating it to the conservation of energy, photons of energy dependent on their frequency and the concept of the work function using relevant equations	2
● Provides some features of Einstein's explanation of the photoelectric effect	1

Sample answer

Einstein used the conservation of energy and Max Planck's quantum theory idea that light was composed of photons of energy ($E=hf$) and said that the energy of the incident photons of light above the frequency that causes the photoelectric effect is equal to the threshold frequency required to cause an electron to be released or the work function (Φ) of the metal surface and the maximum kinetic energy of that released photoelectron. This is described by the equation $hf = \Phi + KE_{max}$.

Question 34
34 (a)

Criteria	Mark
• Correctly identified the motor as a DC motor	1

Sample answer

DC motor because it has a split ring commutator.

34 (b)

Criteria	Marks
• A detailed response identifying the similarity in construction, the role of the emf in both devices and the effect of the generated emf or current in both devices	2
• One point of relevant comparison	1

Sample answer

DC motors and generators are similar in construction in that they have a split ring called a commutator. The commutator for both is attached to electrical contacts called brushes. All motors are effectively generators. In generators the energy input is mechanical and produces electricity. In motors the energy input is electricity and the output is mechanical energy. The changing direction of the current through the commutator causes the armature and thus the loops to rotate in a motor. The magnetic field the armature turns in generators and motors may be permanent magnets or electromagnets. In DC generators the generated emf is direct current, while in a DC motor the supply emf is a DC current. The emf produced in a generator increases its efficiency, but the produced back emf in a motor contributes to energy waste and inefficiency in its performance.

34(c)

Criteria	Marks
• A correct calculation of the maximum torque and a correct determination of the direction of coil rotation	3
• A correct calculation of the maximum torque and an incorrect determination of the direction of coil rotation or an incorrect calculation of the maximum torque due to a substitution error with a correct determination of the direction of coil rotation	2
• A correct determination of the direction of coil rotation	1

Sample answer

$$\tau_{max} = nIAB = 10 \times 0.5 \text{x} (0.05\ x\ 0.03) \text{ x1} = 7.5 \times 10^{-3} Nm$$

$$\tau_{max} = nIAB = 10 \times 0.5 \times 0.05 \times 0.03 = 7.5 \times 10^{-3} Nm$$

From the right hand rule the coil will rotate in an anticlockwise direction.

Question 35

35 (a)

Criteria	Marks
• A correct calculation of the orbital period of the satellite recognising the application of Kepler's laws of planetary motion to elliptical orbits	3
• Two relevant calculations with a substitution error	2
• A relevant calculation	1

Sample answer

$r_{satellite} = r_E + 300000\ m$ which is the semi major axis of the elliptical orbit.

$$r_{satellite} = 6.371 \times 10^6 m\ + 300000\ m = \ 6.671 \times 10^6 m$$

Because Kepler's laws of planetary motion apply to elliptical orbits as well as circular

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

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

$$T = \ 5412\ s$$

35(b)

Criteria	Marks
• A correct determination of the total energy of the satellite	2
• An incorrect determination of the total energy of the satellite with an incorrect substitution	1

Sample answer

Total energy = U + K = -GMm/2r = $-6.67\text{x}10^{-11}$ x $6\text{x}10^{24}$ x 100 / (2 x 6671000) = -3.00×10^{9} J

where r is the semimajor axis of the satellite or its average altitude.

35 (c)

Criteria	Marks
• A correct determination of the average velocity of the satellite	2
• An incorrect determination of the average velocity of the satellite with one incorrect substitution into the correct equation	1

Sample answer

$v = \frac{2\pi r}{T}$ where r is the semi major axis of the ellipse.

$$v = \frac{2\pi \times 6.671 \times 10^6}{5412}$$
$$v = 7.745 \times 10^3 ms^{-1}$$

Question 36

36 (a)

Criteria	Marks
• Provides an extensive description of how the H-R diagram can be used to determine the characteristics and evolutionary stage of a star	3
• Provides an incomplete description of how the H-R diagram can be used to determine the characteristics and evolutionary stage of a star	2
• Describes how the H-R diagram can be used to determine the characteristics or evolutionary stage of a star	1

Sample answer

Depending on its initial mass, every star goes through specific evolutionary stages dictated by its internal structure and how it produces energy. Each of these stages corresponds to a change in the temperature and luminosity of the star. Through its life a star will plot on different regions on the HR diagram as it evolves. Astronomers can know a star's internal structure and evolutionary stage simply by determining its position in the diagram.

36 (b)

Criteria	Marks
● A complete outline of how the Hertzsprung-Russell diagram can be used to identify the classification of a star	2
● An incomplete outline of how the Hertzsprung-Russell diagram can be used to identify the classification of a star	1

Sample answer

Astronomers use H-R diagram to classify stars according to their luminosity, spectral type, color and temperature. By splitting the light from a star through a spectrograph a star's spectrum can be recorded and analysed. Stars of similar temperature, are classified into the same spectral class. The main spectral classes for stars range from O (the hottest) through B, A, F, G, K and M (coolest).The temperature of a star is determined from measuring the star's brightness in two different filters and comparing the ratio of red to blue light. This determines where the star plots on the x-axis of the H-R diagram and hence its spectral class.

36 (c)

Criteria	Marks
● Outlines how the Main Sequence is a predictive tool for describing the life cycle of most stars	2
● Provides a piece of relevant information about how the Main Sequence is a predictive tool for describing the life cycle of most stars	1

Sample answer

Not all stars have the same initial mass. Stars of higher initial mass plot along the main sequence at specific evolutionary stages dictated by the internal structure of the star and how it produces energy. Each of these stages corresponds to a change in the temperature and luminosity of the star hence the star will plot to different regions on the HR diagram as it evolves. This reveals the true power of the HR diagram – astronomers can know a star's internal structure and the nature of its power source nuclear reactions and life cycle stage simply by determining its position in the diagram. A star cannot go backwards along the Main Sequence only from right to left on the H-R diagram. Its future can therefore be predicted.

36 (d)

Criteria	Marks
● Outlines what is meant by the proton - proton chain	2
● Outlines a relevant feature of the proton - proton chain	1

Sample answer
The proton-proton chain describes a set of thermonuclear reactions in which hydrogen nuclei (protons) fuse to form deuterium; these then fuse to form light helium isotopes, releasing more hydrogen nuclei that undergo further fusion with each other and with other nuclei.

2020 Higher School Certificate
Trial Examination
Physics Mapping Grid
Section I

Question	Marks	Content	Syllabus Outcomes
1	1	Mod 6 Electromagnetic induction	PH12-5, PH12-13
2	1	Mod 5 Projectile Motion	PH12-2, PH12–12
3	1	Mod 5 Motion in gravitational fields	PH12-4, PH12-5, PH12-12
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 Motion in gravitational fields	PH12-4, PH12-5, PH12-12
7	1	Mod 6 Motor effect	PH12-4, PH12-5, PH12-13
8	1	Mod 5 Applications of the electric motor	PH12-4, PH12-5, PH12-13
9	1	Mod 5 Circular motion	PH12-4, PH12-5, PH12-12
10	1	Mod 6 Applications of the motor effect	PH12-4, PH12-5, PH12-13
11	1	Mod 5 Projectile motion	PH12-4, PH12–12
12	1	Mod 7 Light and special relativity	PH12-6, PH12–14
13	1	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-4, PH12-13
14	1	Mod 7 Light and the wave model	PH12-5, PH12-14
15	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-5, PH12-13
16	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-4, PH12-6, PH12-13
17	1	Mod 8 Deep inside the atom	PH12-6, PH12-15
18	1	Mod 7 Light and special relativity	PH12-5, PH12-7, PH12-14
19	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-13
20	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-5, PH12-15

Section II

Question	Marks	Content	Syllabus Outcomes
21	3	Mod 5 Circular motion	PH12-5, PH12-12
22	3	Mod 5 Motion in gravitational fields	PH12-4, PH12-7, PH12-12
23	3	Mod 5 Motion in gravitational fields	PH12-5, PH12-12
24	3	Mod 5 Circular motion	PH12-5, PH12-6, PH12-12
25(a)	1	Mod 8 Properties of the nucleus	PH12-4, PH12-15
25(b)	2	Mod 8 Properties of the nucleus	PH12-4, PH12-7, PH12-15
25(c)	2	Mod 8 Properties of the nucleus	PH12-5, PH12-6, PH12-15
26(a)	2	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-4, PH12-7, PH12-13
26(b)	3	Mod 6 Charged particles, conductors and electric and magnetic fields	PH12-4, PH12-5, PH12-13
27(a)	3	Mod 7 Light wave model	PH12-1, PH12-2, PH12-14
27(b)	2	Mod 7 Light wave model	PH12-3, PH12-6, PH12-7, PH12-14
28 (a)	1	Mod 5 Projectile motion	PH12-5, PH12-12
28 (b)	2	Mod 5 Projectile motion	PH12-3, PH12-12
28(c)	2	Mod 5 Projectile motion	PH12-4, PH12-12
29(a)	3	Mod 8 Origins of the elements	PH12-5, PH12-6, PH12-15
29 (b)	2	Mod 8 Origins of the elements	PH12-5, PH12-6, PH12-15
30 (a)	1	Mod 7 Wave model	PH12-1, PH12-3, PH12-14
30(b)	1	Mod 7 Wave model	PH12-2, PH12-3, PH12-14
30(c)	3	Mod 7 Light wave model	PH12-7, PH12-14
31	5	Mod 7 Light and special relativity	PH12-1, PH12-7, PH12-14
32 (a)	3	Mod 5 Motion in gravitational fields	PH12-4, PH12-5, PH12-12
32 (b)	2	Mod 5 Motion in gravitational fields	PH12-7, PH12-12

Question	Marks	Content	Syllabus Outcomes
33 (a)	3	Mod 6 Light: Quantum model	PH12-2, PH12-13
33 (b)	3	Mod 6 Light: Quantum model	PH12-7, PH12-13
34 (a)	1	Mod 6 Applications: Motor effect	PH12-5, PH12-13
34 (b)	2	Mod 6 Applications: Motor effect	PH12-4, PH12-13
34(c)	3	Mod 6 Applications: Motor effect	PH12-4, PH12-13
35 (a)	3	Mod 5 Motion in gravitational fields	PH12-4, PH12-12
35 (b)	2	Mod 5 Motion in gravitational fields	PH12-4, PH12-12
35 (c)	2	Mod 5 Motion in gravitational fields	PH12-4, PH12-7, PH12-12
36 (a)	3	Mod 8 Origins of the elements	PH12-4, PH12-7, PH12-15
36 (b)	2	Mod 8 Origins of the elements	PH12-7, PH12-15
36 (c)	2	Mod 8 Origins of the elements	PH12-5, PH12-15
36 (d)	2	Mod 8 Origins of the elements	PH12-7, PH12-15