Exam Choice

Student Number

2021 | 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 – 10)

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

Section II – 80 marks (pages 11 – 26)

- Attempt questions 21 – 37
- Allow about 2 hours and 25 minutes for this section.

Section I – 20 marks

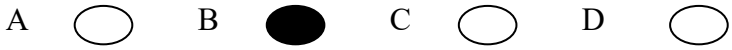
Attempt Questions 1-20

Allow about 35 minutes for this section

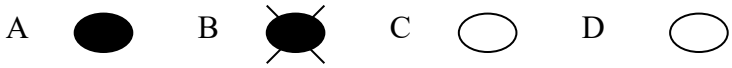
Use the multiple-choice answer sheet.

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

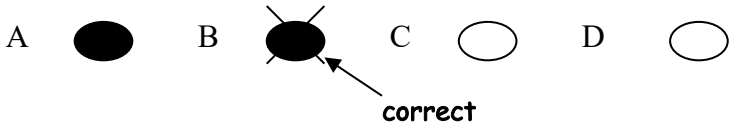
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9



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.



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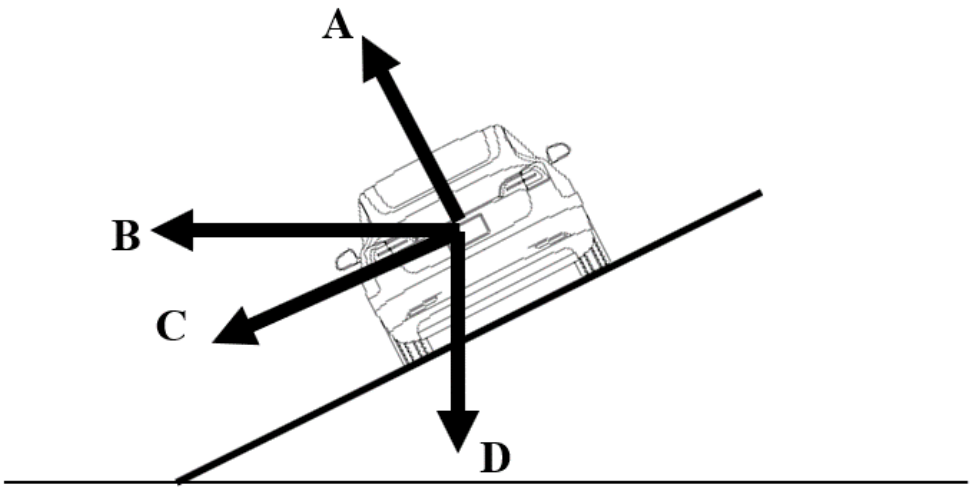
1. A vehicle is moving around a horizontal circular track which is banked, as shown.

Its speed is constant and it stays at the same height on the track as it moves.



Which arrow correctly represents the net force acting on the vehicle?

(A) A

(B) B

(C) C

(D) D

2. What is the magnitude of the gravitational force acting on a 3.50×10^3 kg satellite orbiting a planet when the satellite's orbital radius is 9.17×10^6 m and the satellite's orbital period is 1.50 hours ?

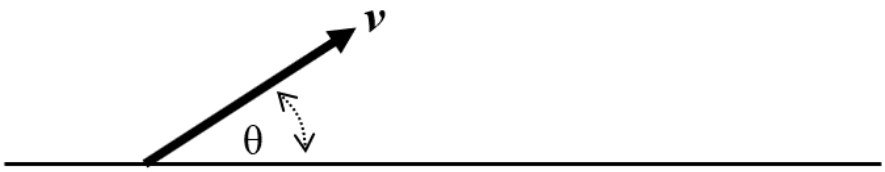
(A) 4.34×10^4 N

(B) 5.63×10^{11} N

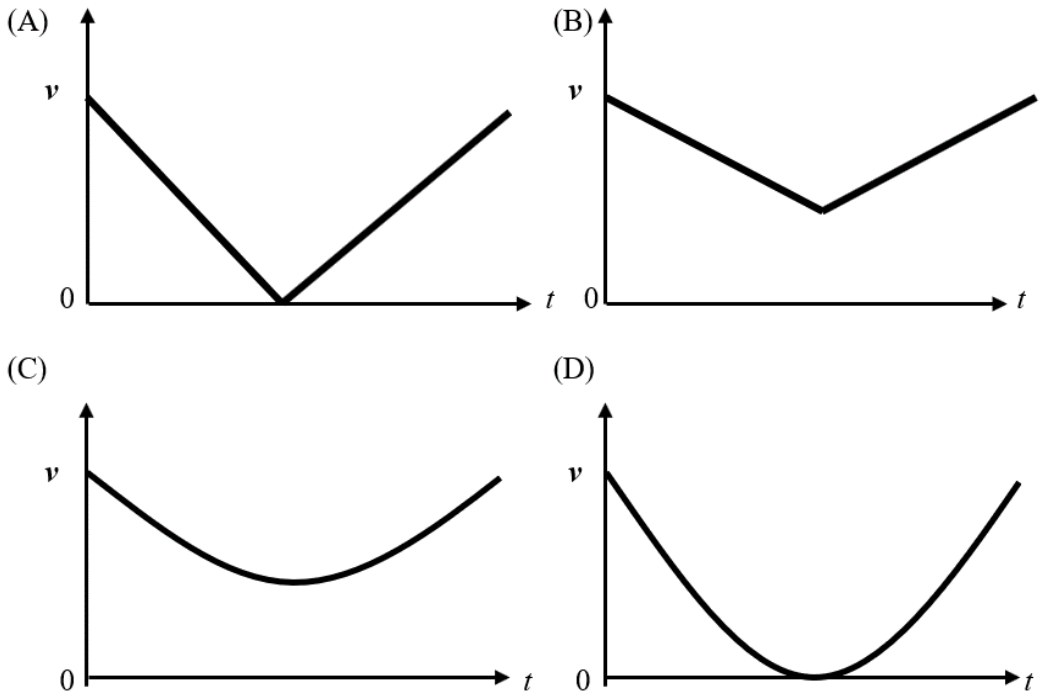
(C) 4.07 N

(D) 1.24×10^4 N

3. A projectile is launched with initial speed v at an angle θ to the horizontal, as shown.



Which graph most closely represents the speed of the projectile during the entirety of its flight?



4. The <u>concept</u> of escape velocity can best be described as:

(A) the initial speed required so that an object will safely orbit the Earth.

(B) the speed required for an object to be launched and fly through space forever.

(C) the speed necessary for a spacecraft to escape Earth's atmosphere.

(D) the velocity needed to provide an initial kinetic energy such that total mechanical energy is zero.

5. The physics underpinning Kepler's second law of planetary motion is:

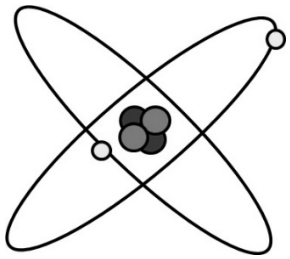
(A) a planet losing kinetic energy as it moves closer to the central body.

(B) a planet's orbit not being a perfect circle.

(C) a planet's orbital radius being proportional to its period.

(D) a planet losing gravitational potential energy as it moves closer to the central body.

6. A diagrammatic representation of a He atom is shown below:



The number of fundamental particles required to construct a complete He atom is:

(A) 6

(B) 10

(C) 14

(D) 16

7. The analogy that best models the concept of magnetic flux is:

(A) the pressure in a water pipe.

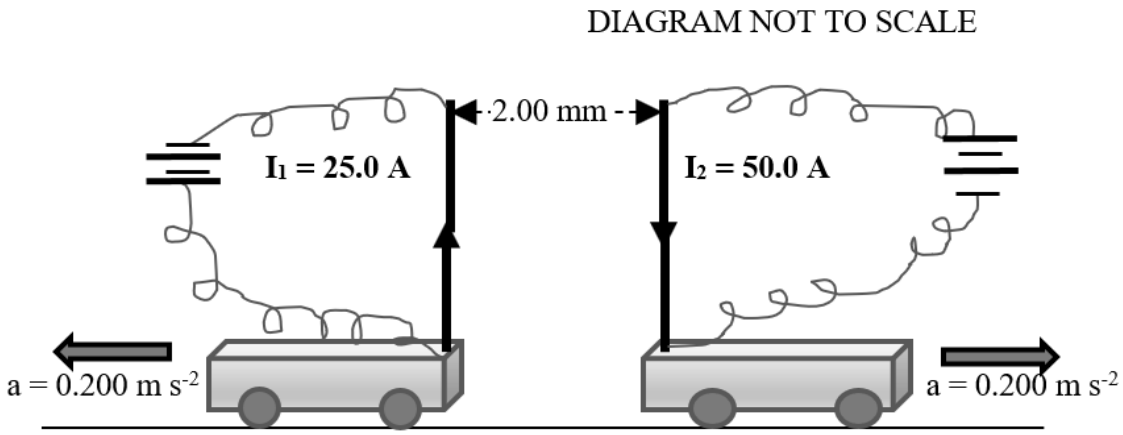
(B) the speed of the water flowing through a pipe.

(C) the flow rate of water through a pipe.

(D) the diameter of a water pipe.

8. Two parallel wires, both 2.00 m long, are placed vertically on two identical frictionless trolleys on a horizontal surface.

When the current is switched on in both wires, the trolleys move away in opposite directions from each other with initial accelerations of 0.200 m s^{-2}.



The mass of each trolley is:

(A) 0.625 kg

(B) 1.25 kg

(C) 2.50 kg

(D) 5.00 kg

9. One application of step-up transformers is in the transmission of electrical energy over long distances.

A doubling of voltage in a long distance transmission line while maintaining the same power being transmitted results in:

(A) half the amount of power being lost as heat.

(B) a doubling in the current being transmitted.

(C) more heat generated in the transmission lines.

(D) a 75% reduction in energy wasted due to the resistance in the transmission lines.

10. Magnetic braking:

(A) only works when there is relative motion.

(B) is due to friction between the magnetic surfaces.

(C) is magnetic attraction between permanent magnets.

(D) works well at slow speeds.

11. One aspect of light that Maxwell's equations does not address is:

(A) the speed of light through a vacuum.

(B) observations associated with the photoelectric effect.

(C) the wave nature of light.

(D) the existence of other wavebands of electromagnetic radiation.

12. The spectra from three different sources are shown below.

I **II** **III**

Which combination correctly identifies the possible sources of the three spectra?

	I	II	III
(A)	sunlight	gas discharge tube	incandescent filament
(B)	sunlight	incandescent filament	gas discharge tube
(C)	gas discharge tube	sunlight	incandescent filament
(D)	incandescent filament	sunlight	gas discharge tube

13. When purchasing polarised sunglasses, the two pairs of sunglasses were held up to a bright light and rotated until they were aligned exactly 90° to each other. A small amount of light was observed to pass through.

This is most likely because:

(A) the light source is also polarised.

(B) the light source is unpolarised.

(C) the light source is monochromatic.

(D) the slits in the polarising material are too wide.

14. In an investigation into the photoelectric effect, yellow light was shone onto the surface of the cathode.

Which of the following changes would result in an increase in the emitted photo electrons' maximum kinetic energy?

(A) Changing the cathode material to a metal with a lower work function.

(B) Changing yellow light to red light.

(C) Increasing the intensity of the incident yellow light.

(D) Decreasing the distance between the cathode and the anode.

15. Schrodinger's advancement of atomic theory:

(A) removed the certainty about the position of electrons in their orbits.

(B) provided certainty regarding the position of electrons in their orbits.

(C) showed that electrons are waves.

(D) showed that electrons are not particles.

16. Which investigation or development allowed the mass of the electron to be found?

(A) The charge of the proton was found.

(B) The mass of the helium nuclei was found.

(C) Millikan's oil drop experiment.

(D) Rutherford's atomic model was developed.

17. In a hypothetical different universe, the Hubble constant is smaller than in our universe.

This implies that the hypothetical universe:

(A) is not sufficiently dense to form stars.

(B) is more compacted than out universe.

(C) did not commence with a Big Bang.

(D) is older than our universe.

18. Given the mass of a helium nucleus is 4.002602 amu, and the Sun produces 3.85×10^{26} W of radiant power, how many helium nuclei are produced in the Sun each second?

(A) 4.278×10^{9}

(B) 8.97×10^{37}

(C) 4.3678×10^{-29}

(D) 3.85×10^{26}

19. A nucleus moving at 10 m s^{-1} possesses 1.00×10^{-24} J of kinetic energy.

The same nucleus within an electric field of strength 1.00 V m^{-1} experiences an acceleration of 4.79×10^{7} m s^{-2}.

How many protons are in this nucleus?

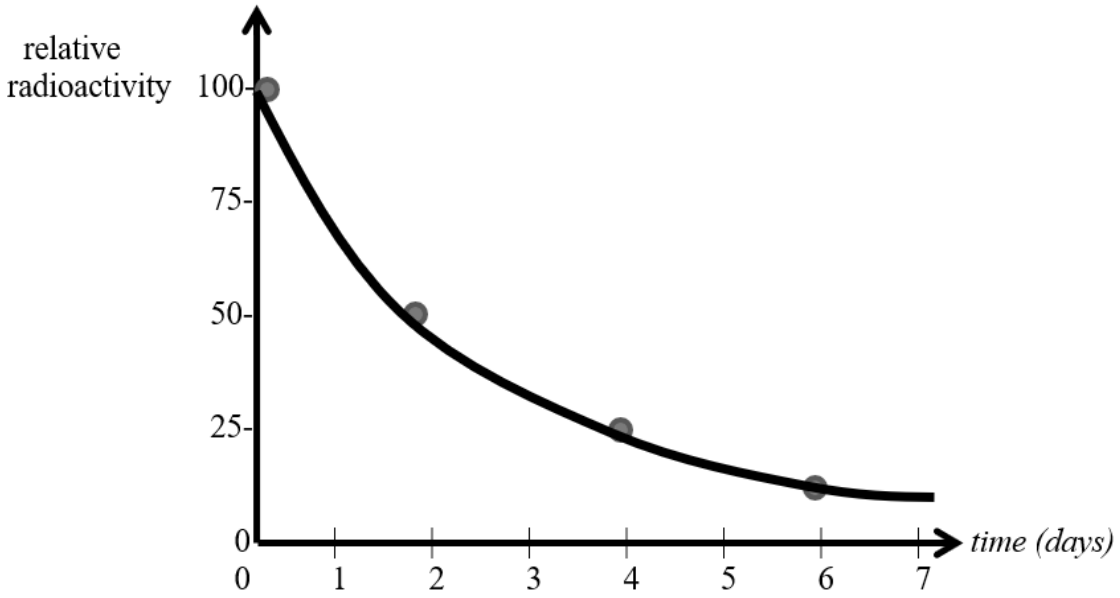
(A) 6

(B) 3

(C) 12

(D) 28

20. A graph of the decay of a radioactive sample is shown.



The decay constant for this sample is closest to:

(A) $0.34\ s^{-1}$

(B) $4 \times 10^{-6}\ s^{-1}$

(C) $2.0\ s^{-1}$

(D) $6.0\ s^{-1}$

2021 | TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks

Attempt Questions 21 – 37

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 **A** is launched at an angle of 20° to the horizontal with initial speed $\boldsymbol{u}$.

Projectile **B** is launched at an angle of 70° to the horizontal, also with an initial speed $\boldsymbol{u}$.

(a) Compare the times of flight of the two projectiles. **2**

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(b) Show that the ranges of both projectiles are equal. **3**

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Marks

Question 22 (4 marks)

In an attempt to make a curve in a road safer, the radius of curvature of the section of horizontal road was doubled.

(a) Given that the curve's original speed limit was 40 km h^{-1}, what should the new speed limit be set to so that the same centripetal acceleration would be experienced? **2**

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(b) Account for the fact that no work is necessary to maintain a satellite in its orbit around Earth. **2**

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Marks

Question 23 (6 marks)

The mass of the Moon is 7.35×10^{22} kg and the distance between the Earth and the Moon is 3.84×10^{8} m.

(a) Qualitatively describe the gravitational force of the Earth on the Moon with the gravitational force of the Moon on the Earth. **1**

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(b) With reference to a relevant formula, explain why a spacecraft would experience a zero net gravitational force at a point closer to the Moon as it travels from Earth to the Moon. **2**

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(c) A spacecraft with mass 4.50×10^{3} kg is in orbit around Earth at an altitude of 5.00×10^{5} m. **3**

How much extra energy does it require from burning its rocket motor so that it could just escape Earth's gravitational field?

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Marks

Question 24 (4 marks)

Astronomers observe a small moon of a planet and find that its average orbital radius is 5.67 x 10^8 m, while its average orbital speed is 2.50 km s^{-1}.

(a) With reference to Kepler's first law of planetary motion, explain why the small moon may not be exactly 5.67 x 10^8 m away from the planet at all times. **1**

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(b) Find the orbital period of the moon and hence the mass of the planet being orbited by the moon. **3**

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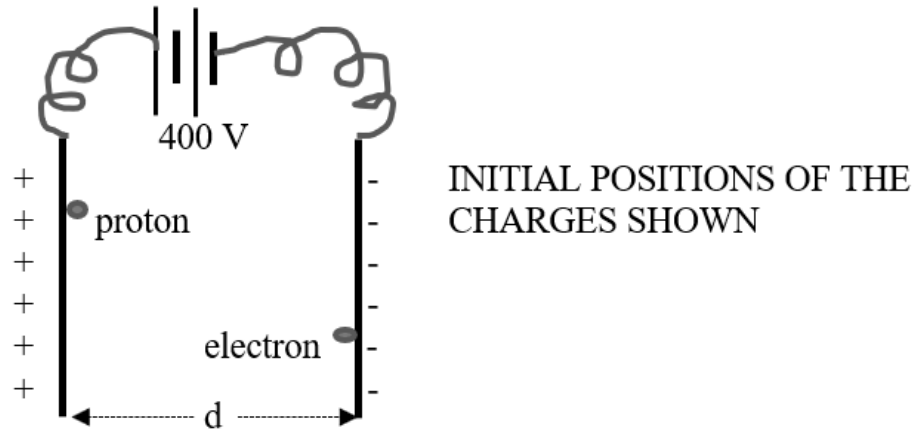
Marks

Question 25 (5 marks)

A proton and an electron are accelerated from one charged parallel plate to the opposite plate. The plates have a potential difference of 400 V, as shown.



(a) Find the final kinetic energy of both the electron and proton given that they were both initially at rest. **2**

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(b) Quantitatively compare the accelerations of both particles as they move between the two charged plates. (assume d = 2 cm) **3**

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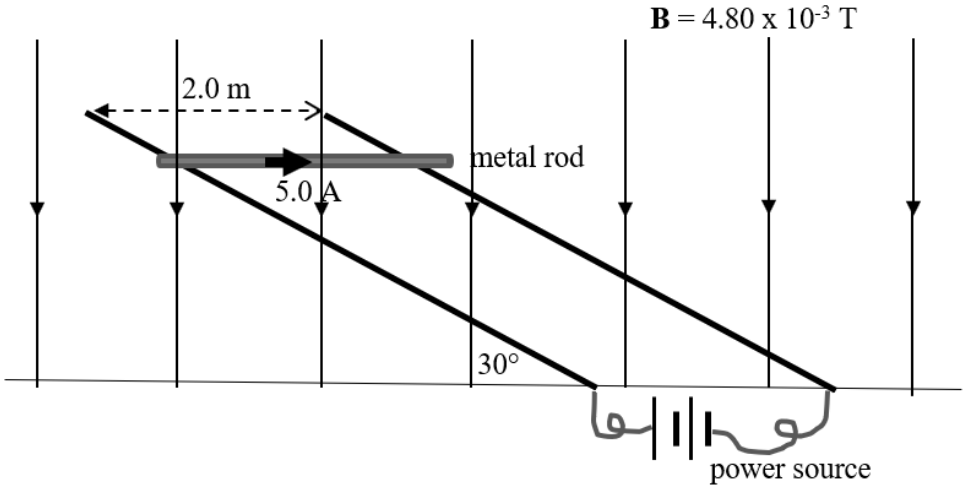
Marks

Question 26 (5 marks)

A straight metal rod sits on parallel metal tracks spaced 2.0 m apart which are angled at 30° to the horizontal. The apparatus exists within a vertical magnetic field of strength 4.80 x 10^{-3} T, as shown.

A current of 5.0 A flows through the metal rod.



(a) Neglecting the effects of gravity, what force would act on the metal rod as it sits motionless on the rails? **2**

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(b) Suggest a procedure that could be used to find the mass of the metal rod, given that gravity is taken into account but friction is ignored. **3**

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Marks

Question 27 (4 marks)

"Lenz's law is simply a consequence of the conservation of energy."

Discuss the validity of this statement and illustrate its meaning with reference to specific examples. **4**

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Marks

Question 28 (4 marks)

With the aid of diagrams, explain the concept of flux linkage and the measures taken to improve it in order to increase transformer efficiency. **4**

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Marks

Question 29 (7 marks)

The production of electromagnetic radiation in the radio waveband relies on the movement of electrons within the transmitting antenna.

(a) Describe how Maxwell's electromagnetic theory is compatible with the methods used to produce radio waveband electromagnetic radiation. **4**

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(b) Describe how the speed of light is related to the current definitions of the dimensions of time and distance, and how it is the same regardless of the relative motion of the source and the observer. **3**

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Marks

Question 30 (6 marks)

Identify the models of light as proposed by Newton and Huygens and explain how observations of light provided the supporting evidence for the models. **6**

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Marks

Question 31 (4 marks)

(a) Using the axes below, graphically describe how the intensity versus wavelength distribution of emitted radiation changes as the temperature of a black body increases. **2**

(b) Prior to Planck's contribution, physics theory was not able to explain black body radiation above certain frequencies.

Describe how the new quantised model of black body radiation differed from the older, classical model. **2**

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Marks

Question 32 (3 marks)

Muons are particles which are produced by the interaction of cosmic ray particles with molecules in the upper atmosphere of the Earth.

Describe how the detection of muons at the Earth's surface provides evidence for special relativity. **3**

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Question 33 (4 marks)

The Big Bang is thought to be the origin of only a small number of different elements found in the universe, yet 94 elements can be found in nature.

Account for the existence of so many elements by outlining the processes which occur in Main Sequence and Post-Main Sequence stars. **4**

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Marks

Question 34 (8 marks)

The model of the atom underwent a number of significant advances from the Dalton model through to the discovery of the neutron by Chadwick.

Outline the experimental procedures employed by Geiger and Marsden as well as Chadwick and the evidence these observations provided to advance the model of the structure of the atom. **8**

Use a diagram or diagrams to illustrate your answer.

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Marks

Question 35 (4 marks)

The Balmer series is one of a number of series of emission lines observed in the spectrum emitted by excited hydrogen gas.

(a) Account for the fact there are multiple lines in the Balmer series, and that series other than the Balmer series exist for hydrogen. **2**

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(b) Calculate the wavelength of the Balmer series emission line with the longest wavelength. All working must be shown. **2**

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Marks

Question 36 (3 marks)

With reference to the helium nucleus, explain why the sum of the masses of the individual constituent particles is greater than the mass of the whole nucleus. **3**

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Question 37 (4 marks) **4**

The Standard Model of Matter refers to the fundamental forces.

With reference to the roles that the each of the fundamental forces play in the structure of the atom, explain how atoms remain intact.

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Section II extra writing space.

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

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Section II extra writing space.

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

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Exam Choice

PHYSICS: Trial Examination 2021

Mapping Grid

Section I

Question	Marks	Content	Syllabus Outcomes (PH 12-)	Target Bands
1	1	Mod 5: Circular Motion	12	3-4
2	1	Mod 5: Circular Motion	12	4-5
3	1	Mod 5: Projectile Motion	12	3-4
4	1	Mod 5: Motion in Gravitational Fields	12	2-3
5	1	Mod 5: Motion in Gravitational Fields	12	3-4
6	1	Mod 8: Deep Inside the Atom	15	3-4
7	1	Mod 6: Electromagnetic Induction	13	4-5
8	1	Mod 6: The Motor Effect	13	3-4
9	1	Mod 6: Electromagnetic Induction	13	4-5
10	1	Mod 6: Applications of the Motor Effect	13	2-3
11	1	Mod 7: Electromagnetic Spectrum	14	2-3
12	1	Mod 7: Electromagnetic Spectrum	14	2-3
13	1	Mod 7: Light: Wave Model	14	3-4
14	1	Mod 7: Light: Quantum Model	14	4-5
15	1	Mod 8: Quant Mech Nature of the Atom	15	3-4
16	1	Mod 8: Structure of the Atom	15	3-4
17	1	Mod 8: Origins of the Elements	15	4-5
18	1	Mod 7: Light and Special Relativity	14	5-6
19	1	Mod 6: Charged Particles	13	4-5
20	1	Mod 8: Properties of the Nucleus	15	5-6

Section II

21		Mod 5: Projectile Motion	12	2-6
22		Mod 5: Circular Motion	12	3-6
23		Mod 5: Motion in Gravitational Fields	6, 12	2-5
24		Mod 5: Motion in Gravitational Fields	12	3-6
25		Mod 6: Charged Particles, Conductors etc	13	3-6
26		Mod 6: The Motor Effect	2, 6, 13	3-6
27		Mod 6: Applications of the Motor Effect	13	2-6
28		Mod 6: Electromagnetic Induction	7, 13	3-6
29		Mod 7: Electromagnetic Spectrum	14	2-5
30		Mod 7: Light: Wave Model	5, 14	2-6
31		Mod 7: Light: Quantum Model	7, 14	2-6
32		Mod 7: Light and Special relativity	6, 14	2-5
33		Mod 8: Origins of the Elements	7, 15	3-6

34		Mod 8: Structure of the Atom	15	2-6
35		Mod 8: Quantum Mechanical Atom	15	2-5
36		Mod 8: Properties of the Nucleus	15	3-5
37		Mod 8: Deep Inside the Atom	7, 15	3-6

Exam Choice

2021 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
B	A	C	D	D	C	C	B	D	A	B	C	D	A	A	C	D	B	A	B

Section II

21 a.

Marking Criteria	Marks
• calculations made and compared correctly	**2**
• calculation of u_y made • OR • method shown that would lead to time of flight, i.e. correct formulae identified	**1**

Use: $v_y = -u_y + a_y t$ as $v_y = -u_y$

Projectile A: Projectile B:

$2u\sin 20° = 9.8t_A$ $2u\sin 70° = 9.8t_B$

$t_A = \dfrac{2u\sin 20°}{9.8}$ $t_B = \dfrac{2u\sin 70°}{9.8}$

$\therefore t_B = \dfrac{\sin 70°}{\sin 20°} t_A$

$t_B = 2.75t_A$

21 b.

Marking Criteria	Marks
• ranges of projectiles are calculated correctly in terms of u • correct conclusion drawn	**3**
• range of projectile is calculated with an error, using u • 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**

range $= u_x \times t$

Projectile A: Projectile B:

$\text{range}_A = u\cos 20° \times \dfrac{2u\sin 20°}{9.8}$ $\text{range}_B = u\cos 70° x \dfrac{2u\sin 70°}{9.8}$

$= 0.0656u^2$ $= 0.0656u^2$

22 a.

Marking Criteria	Marks
• Correct answer provided	**2**
• A relevant step is shown with a correct formula used	**1**

$a_c = \frac{v^2}{r}$ So: $\frac{v_1^2}{r} = \frac{v_2^2}{2r}$

$v_2^2 = 2v_1^2$

$v_2 = \sqrt{3200}$

$v_2 = 56.6 \text{ km h}^{-1}$

22 b.

Marking Criteria	Marks
• Correct reasons cited in detail	**2**
• A correct aspect provided, e.g. only force is F_c	**1**

Answers may include:
The only force acting on the satellite is gravity which provides centripetal force, always at 90° to the instantaneous velocity of the satellite. As W=F.s cos 90°, and cos90°=0, the work done on the satellite =0 by the force of gravity, allowing the satellite to remain in orbit with no work being done.

23 a.

Marking Criteria	Marks
• Correct description provided	**1**

The gravitational force of the Earth on the Moon is equal and opposite to the gravitational force of the Moon on the Earth.

23 b.

Marking Criteria	Marks
• Detailed explanation provided	**2**
• One correct aspect/contributing factor identified	**1**

At some point between the Earth and the Moon, the two bodies' gravitational forces would cancel each other as they are in opposite directions, resulting in a net zero force. As the Earth's mass is many times greater than the Moon's, this point in space will be much closer to the Moon than the Earth. This is because the force of gravitational attraction is given by $F = G\frac{m_1 m_2}{r^2}$ where m_1 is the mass of any object, and m_2 being the mass of either the Moon or the Earth.

23 c.

Marking Criteria	Marks
• Correct answer provided	**3**
• An answer provided with an error made	**2**
• One correct aspect towards answer is evident	**1**

In its orbit, the satellite's total energy is:

$U+K = -\dfrac{GMm}{2r}$, therefore, extra energy required to boost satellite will give it total U+K=0

So, extra energy required = $\dfrac{GMm}{2r}$

$$= \frac{6.67\times10^{-11}\times(6.0\times10^{24})\times(4.50\times10^{3})}{2\times(6370+500)\times10^{3}}$$

$$=1.3\times10^{11}\ \text{J}$$

24 a.

Marking Criteria	Marks
• Correct referenced response given	**1**

Kepler's first law says that planets' orbits are elliptical – so the small moon may be closer or further from the planet in its elliptical orbit.

24 b.

Marking Criteria	Marks
• Correct answer provided	**3**
• An answer provided with an error or omission	**2**
• A correct step taken towards obtaining the answer	**1**

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

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

$$= \frac{2\pi\times5.67\times10^{8}}{2.5\times10^{3}}$$

$$=1.425\times10^{6}\ \text{s}$$

then

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

$$M = \frac{4\pi^2 r^3}{GT^2}$$

$$= 5.31\times10^{25}\ \text{kg}$$

25 a.

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

KE is the work done on both charges: W = qV

= 1.6 x 10^{-19} x 400

= 6.4 x 10^{-17} J for both charges

25 b.

Marking Criteria	Marks
• Both accelerations found and compared	**3**
• Accelerations found with error made	**2**
• E field strength found	**1**

Use: $a = \frac{F}{m}$ and $F = qE$ and $E = \frac{V}{d}$:

So: $a = \frac{Vq}{dm}$

electron: $a = \frac{400 \times 1.6 \times 10^{-19}}{0.02 \times 9.1 \times 10^{-31}}$

$= 3.52 \times 10^{15}$ m s^{-2}

proton: $a = \frac{400 \times 1.6 \times 10^{-19}}{0.02 \times 1.67 \times 10^{-27}}$

$= 1.92 \times 10^{12}$ m s^{-2}

The force on both particles is the same – the difference in their masses accounts for the difference in their accelerations.

26 a.

Marking Criteria	Marks
• Correct magnitude and direction of force provided	**2**
• Magnitude of force only OR • magnitude and direction of force given with an error made	**1**

$F = lI_{\perp}B$
$= 2.0 \times 5.0 \times 4.80 \times 10^{-3}$
$= 4.80 \times 10^{-2}$ N horizontally to the left (or similar statement of direction)

26 b.

Marking Criteria	Marks
• Appropriate procedure outlined with reference to the forces involved	**3**
• Several appropriate steps outlined with reference to some of the forces involved	**2**
• An aspect of an appropriate procedure outlined, a reference to a force included	**1**

The component of the metal rod's weight acting down the inclined rails is $mg\sin\theta = 4.9m$ (as $\theta = 30°$)
By varying the current flowing through the rod, the force $F = lI_{\perp}B$ opposes the force down the rails until the rod does not slide. The component acting against the motion is $lIB\cos\theta$ where θ is the angle of inclination of the rails, so: $m = lIB\cos30°/4.9$ where $l = 2.0$ m and B is 4.80×10^{-3}T

27

Marking Criteria	Marks
• Lenz's law is explained clearly with at least 2 specific examples cited • Conservation of energy used to explain Lenz's law in examples used	**4**
• Lenz's law is explained with reference to a specific example • Conservation of energy linked to outcome predicted by Lenz's law	**3**
• Lenz's law is identified and one example cited	**2**
• An aspect of Lenz's law is referenced	**1**

Answers may include:
Lenz's law stated that the direction of an induced current is such that it opposes the change that is inducing the current. When a bar magnet is approaching an end of a solenoid, the induced EMF in the coils of the solenoid cause a current to flow in the coils if an electric circuit exists. The direction of this current produces a magnetic field that repels the approaching magnet. The direction of this current is predicted by Lenz's law. The electric energy produced in the solenoid's coils originated from the work done in pushing the bar magnet towards the coil. If the current flowed in the other direction, the magnet would be drawn towards the solenoid and obtain kinetic energy with no other energy input into the system, violating the conservation of energy. Electromagnetic braking is also predicted by Lenz's law – if it were the other way, the braked disc would not brake but rotate faster, again obtaining energy with no other energy input.

28

Marking Criteria	Marks
• Flux linkage is clearly explained • Structure of a transformer and how flux linkage is improved is described clearly • Diagram used is clear and referenced by the supporting text or annotations	**4**
• Flux linkage is explained • Structure of a transformer and how flux linkage is improved is shown • Diagram used is referenced by the supporting text or annotations	**3**
• Flux linkage is outlined • Its role in a transformer is described • A diagram is used	**2**
• An aspect of either flux, flux linkage or the structure of a transformer is identified	**1**

e.g.

Flux linking two transformer coils

As can be seen in the diagram, the flux generated within the primary coil of the transformer is linked to the secondary coil using a laminated soft iron core. Soft iron has a high magnetic permeability, so the flux tends to remain within the core and not "leak" out, increasing the efficiency of the transformer. The laminations help to minimise eddy currents which generate heat, and thus efficiency is increased. An ideal transformer would have 100% flux linkage with no flux leakage, but such an achievement is not possible.

29 a.

Marking Criteria	Marks
• Maxwell's theory e/m radiation described • Link to electric field and the force on electrons in a wire • Vibration of electrons linked to production of radio wave energy	**4**
• As above, with one idea missing	**3**
• Several aspects of Maxwell's theory and electron motion identified	**2**
• An aspect of either Maxwell's e/m theory or vibration of electrons in an antenna is identified	**1**

Maxwell's mathematical description of electromagnetic theory described it as being self-propagating perpendicular oscillating electric and magnetic fields. Electrons in a conductor which are being forced to oscillate by an electric circuit producing an oscillating electric field in the conductor are accelerating, and thereby produce electromagnetic radiation, which propagates away through space at the speed of light.

29 b.

Marking Criteria	Marks
• Speed of light is defined • Metre and second defined • Reason for speed being measured with the same value outlined	**3**
• Speed of light defined • Metre and/or second defined	**2**
• An aspect of the speed of light is correctly stated	**1**

The speed of light is defined as being 299,792,458 m s^{-1}. The metre is defined as how far light travels in 1/299,792,458th of a second. A second is defined in terms of the frequency of a Cs-133 atom. Due to length contraction (if there exists relative motion between source and observer) and time dilation, a source of light moving relative to the observer will still have the same speed of light measured as if there were no motion. Hence the speed of light is constant using this definition.

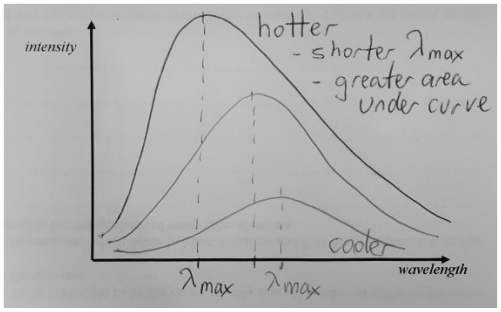
30

Marking Criteria	Marks
• Newton's and Huygens' models described • Several observations supporting each model attributed, with reasons given	**6**
• Newton's and Huygens' models outlined • Several observations supporting each model attributed	**4-5**
• Newton's and Huygens' models identified • An observation supporting each model attributed	**3**
• Newton's and Huygens' models identified OR • one model correctly identified with a supporting observation	**2**
• An aspect of either Newton's or Huygens' model is identified	**1**

Newton's particle (corpuscle) model of light was supported by observations such as reflection, where the particles simply bounced off a surface. Refraction was explained by the light particles being sped up as they entered the more dense medium, having been drawn into the medium.
Huygens' wave model was supported by observations of interference, only possible with a wave. Interference occurs due to the superposition of two (or more) waves coinciding, where the resultant displacement is the algebraic sum of the displacements of the constituent waves. A particle model at the time could not explain interference. Reflection of waves also fitted this model, as displayed with water waves hitting a wall. Refraction was explained by a slowing down of the waves as they entered a more dense medium. Polarisation of light, while it could be explained with a particle model, was better suited to a wave model of light, as transverse waves can be polarised easily by being passed through parallel slits.

31 a.

Marking Criteria	Marks
• Correct shape of curves (at least 2) shown • Correct trends in curves clear	**2**
• One correct aspect of a black body curve is evident	**1**



λ_{max} gets shorter with increasing temperature; area under curve and maximum intensity increases with increasing temperature.

31 b.

Marking Criteria	Marks
• Quantised model of black body radiation clearly described and compared to classical model	**2**
• An aspect of either quantised or classical black body radiation is identified and described	**1**

The older, classical model of black body radiation was a continuous emission by waves, whereas Planck's quantised model describes the energy given off in quanta – small discrete packets of energy, with each quanta having energy proportional to its frequency of the radiation it is carrying.

32

Marking Criteria	Marks
• The nature of muons is described • Reasons why muons should not be expected at the surface explained • Relativistic effects related to muon detection at surface and explained clearly	**3**
• Nature of muons outlined • Appropriate relativistic effect identified	**2**
• Nature of muons outlined OR • appropriate relativistic effects identified	**1**

Muons, once formed in the upper atmosphere as cosmic rays collide with gas molecules, have a half-life so short that, even if travelling near the speed of light towards the surface, should have decayed before reaching the surface. However, the number of muons detected at the surface is much greater and can be accounted for once the effects of time dilation (i.e. time for the observed muon is running slower) and length contraction (from the muon's frame of reference, the distance to the surface is much shorter) are accounted for. These relativistic effects mean that, due to the muons' high speeds, many are detected at the surface.

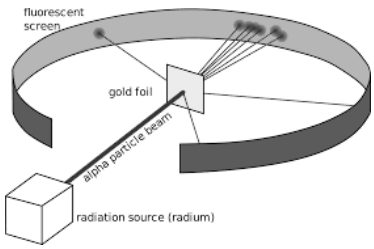
33

Marking Criteria	Marks
• Both proton-proton chain and CNO cycle outlined • Post main-sequence star nucleosynthesis is outlined • Existence of other elements accounted for	**4**
• As above, with an omission	**3**
• Several aspects of nucleosynthesis within stars are outlined	**2**
• An aspect of nucleosynthesis within stars is identified	**1**

e.g. In main sequence stars, the core has such high density and temperature that hydrogen nuclei are fused into helium nuclei by either the proton-proton chain or CNO cycle in a step-wise process. In the hotter cores where C exists, the CNO cycle is thought to be the dominant pathway for fusion where C acts as a catalyst, with a step-wise process moving through with N and O nucleii produced until the net reaction is the same as the proton-proton chain. Once the hydrogen becomes depleted, post-main sequence star cores begin to fuse the He into heavier nucleii up to and including Fe, where the process cannot continue in these stars as it becomes endothermic and thus unsustainable.

34

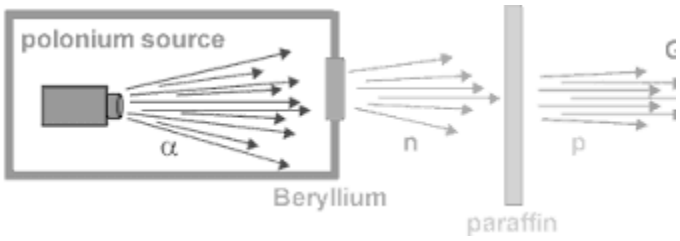
Marking Criteria	Marks
• Both experimental procedures outlined clearly • Experimental evidence from both experiments described • Atomic models and the advances resulting described clearly • Diagrams used clarify the response	**8**
• Both experiments outlined • Experimental evidence from both experiments outlined • Advance of one atomic model outlined • Diagrams used	**6-7**
• Both experiments outlined • Evidence from either experiment described • Advancement of atomic model from either experiment outlined	**4-5**
• Several spects of either the experiments, the observations or the models of the atom are outlined	**2-3**
• An aspect of either experiment identified OR • An aspect of either experimental observations identified OR • An aspect of one of the models of the atom identified	**1**



Answers may include:

- Geiger and Marsden conducted the alpha-particle gold foil scattering experiment where alpha particles were fired at a thin foil of gold and then detected, as shown in the diagram.
- While most alpha particles passed through the foil, a few were deflected while a very few surprisingly rebounded.
- Analysis of the results led to the conclusion that the gold atoms had almost all their mass and all of their positive charge contained in a very small central “nucleus”. The electrons were though to occupy the remaining volume of the atom as they orbited the central nucleus like planets orbiting the Sun.

- However, classical physics predicted that these accelerating electrons would emit radiation, lose energy and spiral into the nucleus which clearly does not happen, as most atoms are stable.
- Chadwick fired alpha particles into a Beryllium target. Behind the Be target he placed paraffin which is a substance that is hydrogen atom rich. This arrangement is shown in the diagram.
- Protons were detected being displaced from the paraffin.
- Some particles with no charge but with mass approximately equal to that of protons was believed to be being displaced from the Be and striking the paraffin; these particles were called neutrons
- The model of the atom was advanced to include neutrons in the nucleus of atoms, thus explaining the existence of isotopes, atoms of the same element with different masses



35 a.

Marking Criteria	Marks
• Complete account is provided for both multiple lines in a series as well as multiple series	**2**
• Incomplete or partial account provided	**1**

The individual lines in the Balmer series are emitted by electrons transitioning from energy levels 3 or higher down to energy level 2. Other series of emission lines occur when electrons fall back to, e.g. level 1 from higher levels, or to level 3 from higher levels, etc

35 b.

Marking Criteria	Marks
• Correct answer provided with full working shown	**2**
• Appropriate calculation attempted OR • the initial and final energy levels identified	**1**

Note: answer without working shown =0
Longest wavelength emission line corresponds with electron falling from n_i=3 to n_f=2 (lowest energy transition):

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$= 1.097\times10^{7}\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$= 1.52\times10^{6}\ \text{m}^{-1}$$

$$\lambda = 6.56\times10^{-7}\ \text{m}$$

36

Marking Criteria	Marks
• Reference to binding energy and mass deficit is clear and includes an explanation • Response is succinct and structured	**3**
• Reference made to both binding energy and mass deficit	**2**
• An aspect of either binding energy or mass deficit is outlined	**1**

The difference between the sum of the masses of the individual constituents and the whole He nucleus is known as mass deficit. The whole nucleus has a smaller mass than the sum of its individual components. Using $\Delta E=\Delta mc^2$, where Δm=mass deficit, the binding energy of the nucleus can be calculated. The binding energy is the energy required to disassemble the He nucleus into its component particles.

37

Marking Criteria	Marks
• Contribution of all four fundamental forces is addressed clearly	**4**
• Contribution of all four forces is identified • OR • Contribution of three of the forces is addressed clearly	**3**
• Aspects of two of the forces are outlined	**2**
• An aspect of at least one fundamental force is identified	**1**

The weak nuclear force is involved in beta decay and nuclear fusion, but is much weaker than the strong nuclear force.
The strong nuclear force holds the particles in the nucleus (nucleons) together, preventing them from repelling and breaking down into their constituent quarks. This force also binds the protons and neutrons to each other
The electromagnetic force gives rise to attraction between the electrons and the protons in the nucleus of the atom. It also produces a repulsive force between the protons, which is overcome by the nuclear forces. Electrons also experience repulsion from each other due to this force.
Gravity has very little influence at all on the structure of the atom due to the very small masses of the particles involved, despite the small distances between them.
Overall, the atom remains intact due to the strong nuclear force binding the nucleus together and the electromagnetic force keeping the electrons in their orbits about the nucleus.