Kotara

Year 12 Physics
Trial HSC Exam

General Instructions

- Reading time – 5 minutes
- Working time – 180 minutes
- Write using black pen
- A Periodic Table and Data Sheet is provided
- Board-approved calculators may be used

Total Marks – 100

Attempt all questions.

Section I – Multiple Choice (20 marks)
- Questions 1 - 20

Section II – Short Answer (80 marks):
- Questions 21 - 34

Section I

20 marks

Attempt Questions 1 - 20

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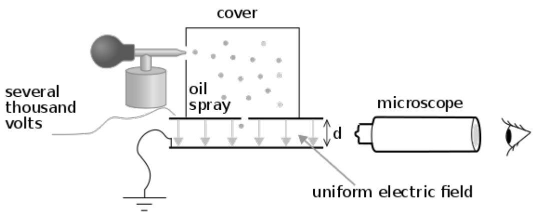
1. Electrons have a charge of 1.602×10^{-19} C. Which experimental setup would allow a physicist to determine this information?

A.



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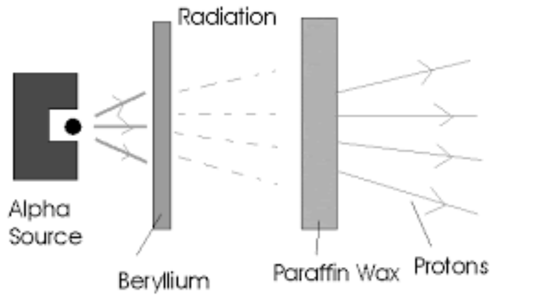

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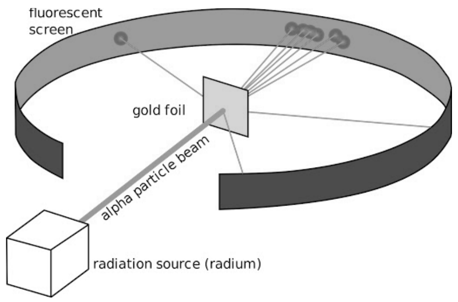

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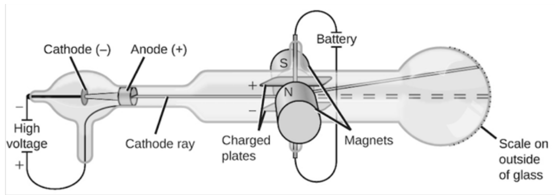


2. In the Standard Model of Matter, muons are classified as:

A. Mesons
B. Baryons
C. Leptons
D. Muons are not a specific particle, they are already a class of particle

3. An object is thrown horizontally at time $t = 0$. At $t = 0.5$ s the object has travelled x metres horizontally and it has fallen y metres vertically.

What is the initial velocity of the object and the vertical distance fallen at $t = 1.0$ s?

	Initial velocity (m s^{-1})	Distance fallen at 1 s (m)
A.	x	$2y$
B.	x	$4y$
C.	$2x$	$2y$
D.	$2x$	$4y$

4. The spectra of two similar stars are compared. One has broader spectral lines than the other. Which statement is most correct?

A. The stars have different rotational velocities.
B. The stars have a different translational velocity from the point of reference of the observer.
C. The stars have the same density.
D. The stars are composed of different elements, which have different width spectral lines.

5. An electron enters a magnetic field with strength 10.0 mT perpendicularly, at 1225 m s^{-1}. What will be the radius of curvature of its path?

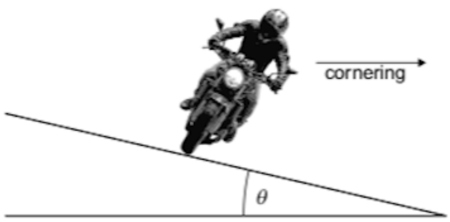
A. 8.5×10^{-4} m
B. 697 nm
C. 6.97×10^{-10} m
D. 69.7×10^{-7} m

6. A pendulum is used to determine the value of acceleration due to gravity. The length of the pendulum is varied, and the time taken for one oscillation at each length is recorded. The period of a pendulum is given by $T = 2\pi\sqrt{\frac{L}{g}}$ where L is its length and g is acceleration due to gravity.

Which of the following could best improve the accuracy of the experiment?

A. Using a stopwatch that measures to nanoseconds rather than milliseconds.
B. Conducting the experiment at different locations on Earth's surface.
C. Recording the time taken for ten oscillations at each length.
D. Changing the mass of the pendulum.

7. A motorcyclist is cornering on a banked, circular track. Which combination of changes in the bank angle θ and the coefficient of friction μ will result in the greatest increase in the motorcyclist's cornering speed?



	Change in θ	Change in μ
A.	Decrease	Increase
B.	Increase	Increase
C.	Increase	Decrease
D.	Decrease	Decrease

8. Given that its rest mass is m, which expression gives the binding energy per nucleon of ${}^{3}_{2}\text{He}$?

A. $(2m_{\text{p}} + m_{\text{n}} + m)c^2$
B. $(2m_{\text{p}} + m_{\text{n}} - m)c^2$
C. $\frac{(2m_{\text{p}}+m_{\text{n}}+m)c^2}{3}$
D. $\frac{(2m_{\text{p}}+m_{\text{n}}-m)c^2}{3}$

9. At one point on Earth's surface at a distance r from Earth's centre, the gravitational field strength is 9.76 N kg^{-1}. What will be the gravitational field strength at an altitude of $2r$?

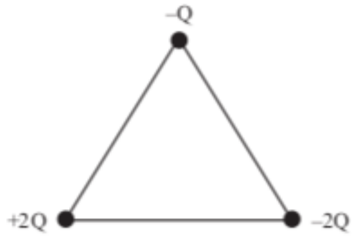
A. 1.08 N kg^{-1}
B. 2.44 N kg^{-1}
C. 3.25 N kg^{-1}
D. 4.88 N kg^{-1}

10. Nuclide X can decay by two routes. In Route 1, X decays via α decay to P and then via β$^-$ decay to a final product of Q. In Route 2, X decays via β$^-$ decay to R and then via α decay to a final product of S.

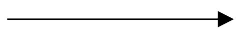
Which statement is correct?

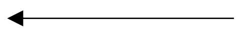
A. Q and S are different isotopes of the same element.
B. X and R have the same mass number.
C. P and R have the same atomic number.
D. X and R are isotopes of the same element.

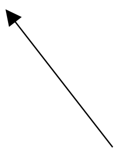
11. The charges -Q, +2Q, and -2Q are placed at the vertices of an isosceles triangle.

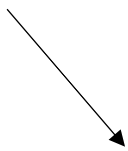


Which of the following best represents the direction of the net force on the charge -Q?

A. 

C. 

B. 

D. 

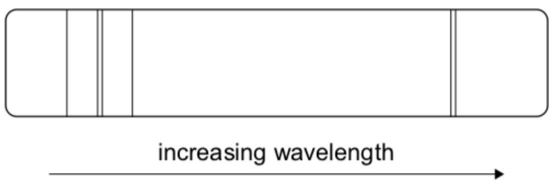
12. A group of students have a data set for the orbital radius and orbital period of the planets in the solar system. Which method should they use to determine the mass of the Sun from their data?

A. Use $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$ with the radius and period of each planet to find M, and average the values.
B. Plot a graph of orbital radius versus orbital period and find the gradient, then use this to calculate M.
C. Plot a graph of the square of the orbital period versus the cube of the orbital radius, then draw a line of best fit, then find the gradient, then find the reciprocal of the gradient, and use this to calculate M.
D. Plot a graph of the square of the orbital period versus the cube of the orbital radius, then draw a line of best fit, then find the gradient, and use this to calculate M.

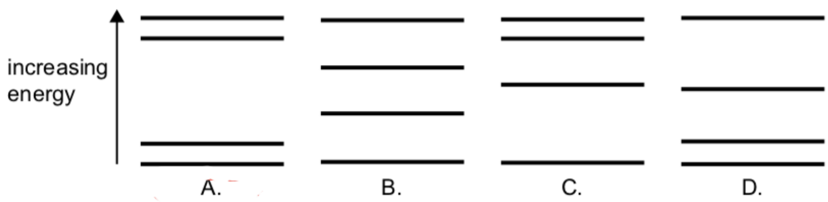
13. A particle of mass 0.02 kg moves in a horizontal circle of diameter 1 m with an angular velocity of 3π rad s^{-1}. What is the magnitude and direction of the force responsible for this motion?

	Magnitude of force (N)	**Direction of force**
A.	$0.09\pi^2$	Away from centre of circle
B.	0.03π	Towards centre of circle
C.	$0.03\pi^2$	Away from centre of circle
D.	$0.09\pi^2$	Towards centre of circle

14. The diagram shows the emission spectrum of an atom.

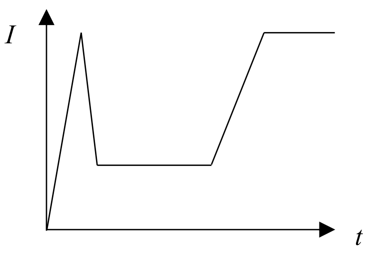


Which of the following atomic energy level models can produce this spectrum?



15. A DC motor initially has no load and rotates at constant speed. It is then placed under a gradually increasing load until eventually it is held still. Which graph best represents the current usage of this motor with respect to time?

A.



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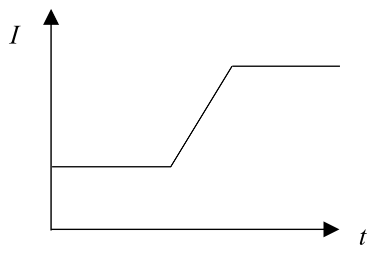

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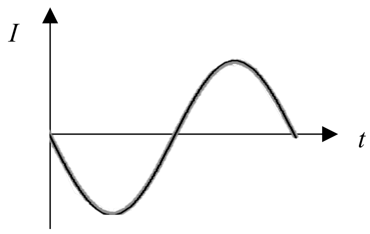

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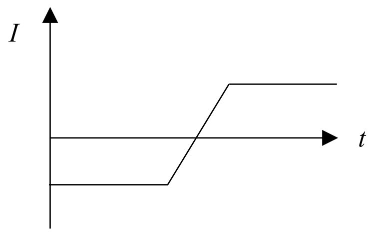
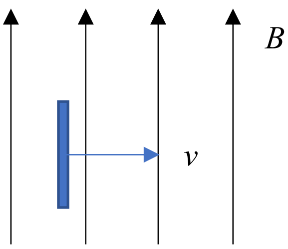


16. A conductive bar travels through magnetic field B at constant velocity v. Whilst this movement occurs, a measurement device travels along the bar in the directions given below. In which direction does the measured electron density in the bar increase?



A. Moving up the page
B. Moving down the page
C. Moving into the page
D. Moving out of the page

17. An observer in Spaceship A watches Spaceship B fly past at a relative speed of $0.943c$ ($\gamma = 3.00$). From the observer's frame of reference, the length of Spaceship B is 150 m. Which is closest to Spaceship B's rest length?

A. 50 m
B. 150 m
C. 450 m
D. 900 m

Questions 18 and 19 refer to the following information.

Some students conducted a practical investigation to experimentally determine the value of Wien's displacement constant, *b*. They used an incandescent light bulb running from 240 V power to approximate a black body radiator. The peak wavelength of their light bulb's emission spectrum was 2×10^{-3} mm.

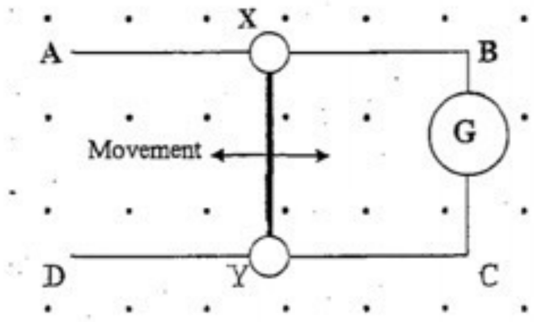
18. In their first trial, a digital sensor measured the temperature of the exterior glass of the bulb, which was 5.2 cm from the actual filament. This yielded a reading of 1900 K. Which best expresses the real value of *b*?

A. $b > 3.8$ m K
B. $b < 3.8$ m K
C. $b < 3.8 \times 10^{-3}$ m K
D. $b > 3.8 \times 10^{-3}$ m K

19. For a second trial, the temperature of the filament was measured accurately using a thermal camera, to a value of 3200 K. However, the incandescent bulb was moving away from the light sensor at 2×10^{4} m s^{-1}. Which best expresses the real value of *b*?

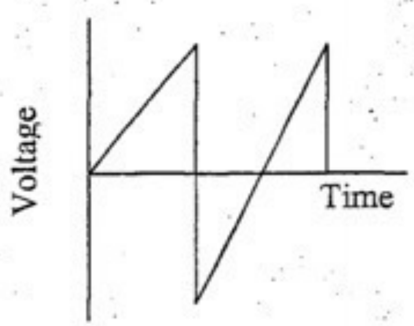
A. $b > 6.4 \times 10^{-3}$ m K
B. $b < 6.4 \times 10^{-3}$ m K
C. $b < 6.4$ m K
D. $b > 6.4$ m K

20. A conductor, ABCD, is situated in a magnetic field. A galvanometer is inserted in side BC and a conducting rod XY connects the sides AB and CD, as shown. The rod XY is able to slide and is moved 5 cm to the left, then 10 cm to the right, and back to its original position.

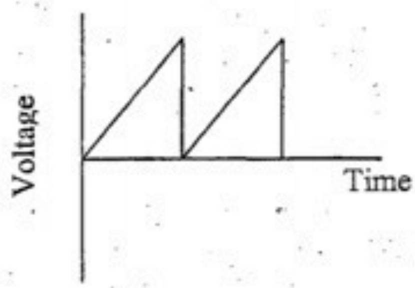


Which graph shows the possible voltage changes that could be observed on the galvanometer?

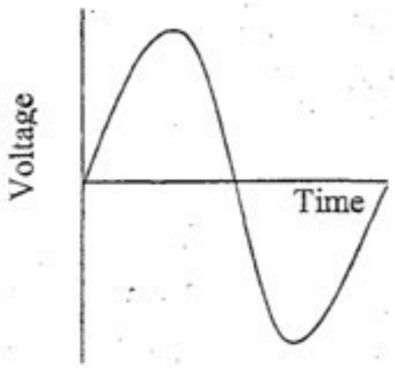
a)



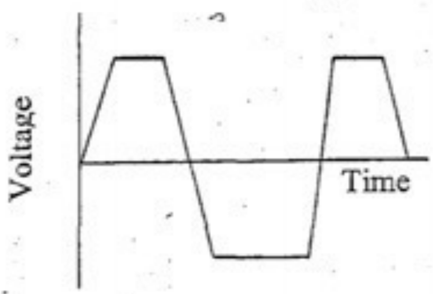
b)



c)



d)



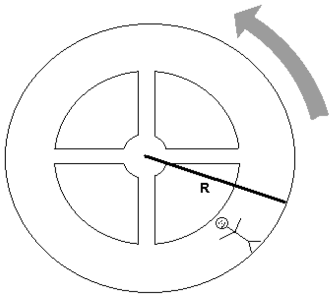
Section II

80 marks

Attempt Questions 21 - 34

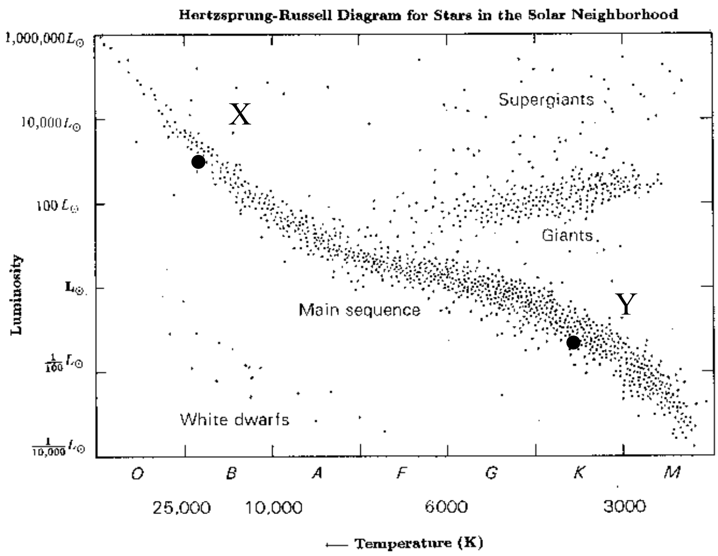
Question 21 (3 marks)

A rotating spacecraft, such as the one shown, can generate artificial gravity for its occupants. It cannot rotate at a rate faster than 0.01 Hz or the occupants will become dizzy. Find the minimum radius of the spacecraft in order for the occupants to feel as if they are on Earth's surface. **3**



Question 22 (11 marks)

X and Y are two main sequence stars, shown on the diagram below.



a) Explain the processes that led to the formation of matter following the Big Bang, and then to the formation of X and Y. **6**

b) The CNO cycle operates according to the following reaction. The mass of a helium nucleus is 4.002602 *u*. Neglecting the mass of electrons and neutrinos, find the energy released in this reaction. **3**

$$^{12}_{6}C + 4^{1}_{1}\mathrm{H} \rightarrow {}^{12}_{6}C + {}^{4}_{2}He + 2{}^{0}_{+1}e + 2v$$

c) In which star, X or Y, is the above reaction most likely to occur? Explain your answer. **2**

Question 23 (3 marks)

A ball is launched at 60 m s^{-1}. At what angles could this occur for it to travel 250 m horizontally? **3**

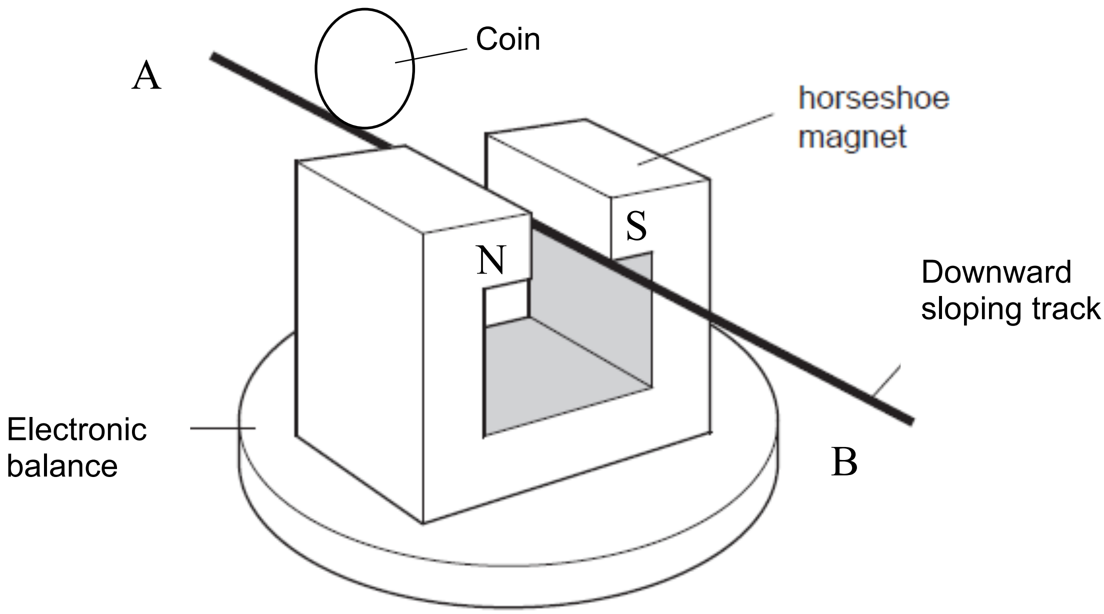
Question 24 (6 marks)

De Broglie's work in physics made substantial contribution to the development of the model of the atom.

a) Show that the radius of the *n*th orbital in a hydrogen atom is equivalent to $\frac{nh}{2\pi mv}$. **2**

b) Outline the experimental evidence that supported de Broglie's contribution, and explain how this addressed a limitation of Bohr's model of the atom. **4**

Question 25 (10 marks)
Identically sized counterfeit coins made of different metals can be detected using the apparatus below. Coins are rolled, from rest, on a track between the poles of a magnet. The time taken for each coin to move from rest at point A to point B is measured with a stopwatch.



The resistance of various coin materials is shown in the table. Assume that the metals have equal density.

Metal	Resistance (Ω m)
Copper	0.20
Aluminium	0.40
Gold	0.10
Silver	0.15

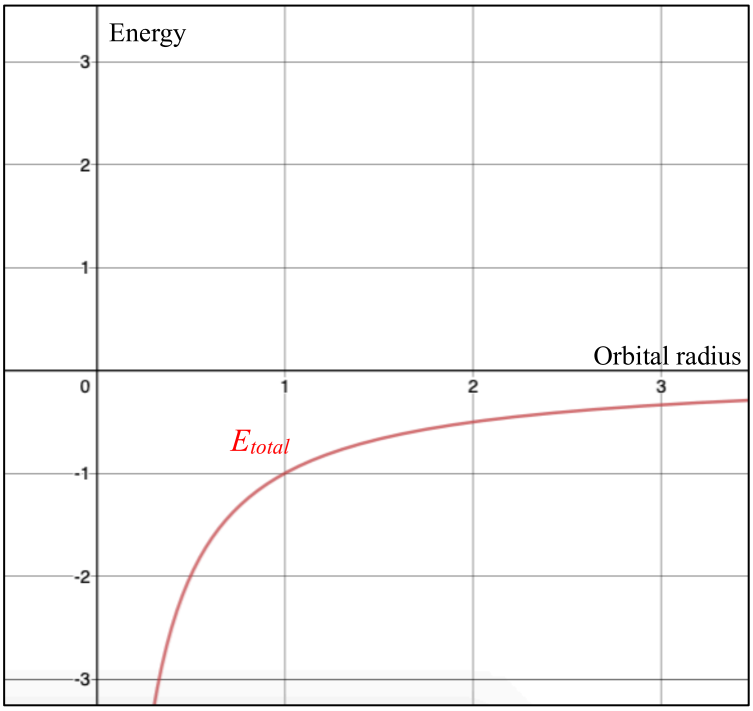
a) Identify what differences would be observed between a copper coin and an aluminium coin, and explain why they occur. **5**

b) A 2 A current is run through the downward sloping track from point A to point B, parallel to the sides of the magnet. The magnetic field strength is 0.5 T, and the length of the track between the poles is 2 cm.

If the electronic balance initially read 200 g, what will its new reading be? **3**

c) A plastic coin starts from rest at point A and is travelling at 23 cm s^{-1} at point B. Calculate the difference in height between points A and B. **2**

Question 26 (5 marks)

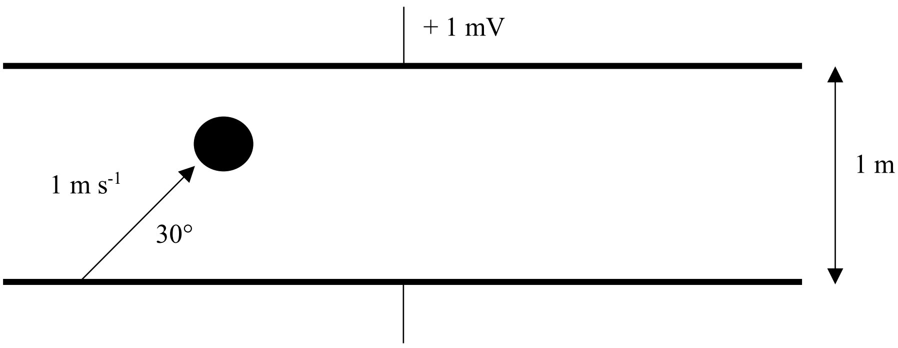


a) The graph shows the total energy of an orbiting satellite versus its orbital radius. Sketch two lines on the graph to show the satellite's kinetic and gravitational energies. **2**

b) Calculate the change in gravitational potential energy when a 300 kg satellite orbiting Earth increases its orbital altitude from 100 km to 200 km. **3**

Question 27 (4 marks)

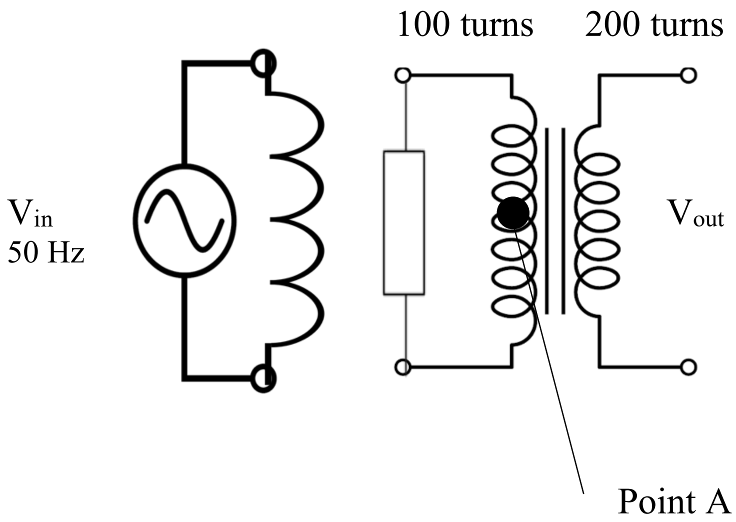
A proton is launched in an electric field, with an initial velocity of 1 m s^{-1} at 30° to the horizontal. The parallel plates are 1 m apart with 1 mV potential difference between them. The procedure is carried out on Earth's surface.



What is the range of the proton? **4**

Question 28 (2 marks)
Light's velocity is not sufficient to escape black holes. Estimate the radius of a black hole with a mass of 10^{50} kg. **2**

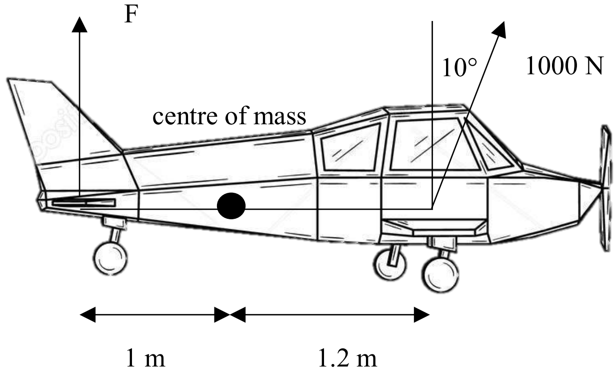
Question 29 (4 marks)
Coil 1 is connected to an AC power source, as shown. When V_{in} is at maximum positive amplitude, the magnetic flux at point A is 0.5 Wb. When it is at maximum negative amplitude the magnetic field has the same magnitude but opposite direction. The AC has a frequency of 50 Hz.



Using the information in the diagram, and assuming ideal conditions, calculate V_{out}. **4**

Question 30 (9 marks)
The electricity grid involves production, conversion, and transmission of electricity. Explain the operation of THREE components of this system. **9**

Question 31 (3 marks)
The forces that act on an aircraft are shown. All forces are in the same horizontal plane.



What must be the magnitude of force F in order for the plane to maintain level flight? **3**

Question 32 (8 marks)
A kaon is a subatomic particle first detected in cosmic rays in 1947. There are four types:

K^- - a negatively-charged particle consisting of a strange quark and an up antiquark
K^+ - a positively-charged antiparticle of the K^- kaon
K^0 - a neutral particle consisting of a strange antiquark and a down quark
K^{0-} - the antiparticle of the K^0.

a) Name the quarks that make up the K^{0-} particle. **1**

b) Use a relevant equation to explain how kaons are accelerated in a synchrotron, and assess a limitation of particle accelerators for investigating K^0 particles. **4**

c) K^- particles have a mean lifetime of 1.238×10^{-8} s in their own frame of reference. Kaons produced in a particle accelerator were found to be moving at 0.850*c*. Calculate their mean lifetime in the frame of reference of a stationary observer. **3**

Question 33 (3 marks)
Describe the production and propagation of electromagnetic waves. **3**

Question 34 (9 marks)
To what extent has our understanding of the nature of light been influenced by experimental evidence? **9**

END OF EXAMINATION

Section II			
Item	**Marks**	**Module**	**Type**
21	4	5	Calculation
22a	6	8	Word
22b	3	8	Calculation
22c	2	8	Word
23	3	5	Calculation
24a	2	8	Calculation
24b	4	8	Word
25a	4	6	Word
25b	3	6	Calculation
25c	2	5	Calculation
26a	2	5	Graph
26b	3	5	Calculation
27	4	6	Calculation
28	2	5	Calculation
29	4	6	Calculation
30	9	6	Word
31	3	5	Calculation
32a	1	8	Word
32b	4	6/8	Word
32c	3	7	Calculation
33	3	7	Word
34	9	7	Word

Section II	
Module 5 marks	20
Module 6 marks	23
Module 7 marks	15
Module 8 marks	22
Total items	22
Average item	3.6 (on par with 2019 HSC)
Calculation items	12 (55%)
Calculation marks	35 (44%)

Trial Exam – Physics
SUGGESTED ANSWERS

Section I

1	2	3	4	5	6	7	8	9	10
A	C	D	A	B	C	B	D	A	B

11	12	13	14	15	16	17	18	19	20
C	C	D	A	C	C	C	D	B	D

Section II

Question 21

$$mg = \frac{mv^2}{r}$$
$$g = \frac{v^2}{r} \text{ but } v = \frac{2\pi r}{T}$$
$$\text{so } g = \frac{2\pi r^2}{T} \times \frac{1}{r}$$
$$r = \frac{gT}{4\pi^2}$$

$$f = 0.01 \text{ Hz, so } T = \frac{1}{f} = 100 \text{ s}$$
$$g = 9.8 \text{ m s}^{-2}$$
$$r = \frac{9.8 \times 100}{4\pi^2}$$
$$r = 24.82 \ldots = 24.8 \text{ m}$$

Question 22

a) Answers should include a combination of:

- Matter/energy in one point of zero volume, infinite density.
- Undergoes rapid expansion with high temperature and pressure.
- As it cools and expands, matter begins forming.
- Fundamental particles form first (quarks, leptons), and the fundamental forces are initially unified.
- Quarks start combining into hadrons, and the strong nuclear force (along with gluons) and gravity begin to exist.
- Electromagnetic force and weak nuclear force begin to exist, along with relevant bosons. Nuclear decay can now occur.
- Matter and antimatter annihilate, leaving just matter.
- This leaves pockets of different densities, and certain higher density gas clouds of light elements.
- Gravity pulls these together and forms denser and denser matter than in turn develops more gravity and orbits.
- These eventually compress enough, with enough pressure and temperature, to sustain nuclear fusion, thus forming stars.

b) net equation: $4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}He$

$$m_{\text{RHS}} = 4.002602\,u$$

$$m_{\text{LHS}} = 4m_{\text{p}} = 4.02889\ ...\ u$$
$$\text{mass defect} = m_{\text{LHS}} - m_{\text{RHS}} = 0.02629\ ...\ u = 4.367\ ... \times 10^{-29}\ \text{kg}$$

$$E = mc^2$$
$$E = 4.367\ ... \times 10^{-29} \times (3 \times 10^8)^2$$
$$E = 3.931027 \times 10^{-12}\ \text{J}$$

c) It will occur in X, because the temperature and mass are higher. Therefore, it is capable of fusing the heavier elements, and it also has C, N, O present. In contrast, the proton-proton chain is predominant in stars like Y because they do not have C, N, O and are lower temperature.

Question 23

$t_{\frac{1}{2}}$ is where $v_v = 0$

$$0 = u_v + at_{\frac{1}{2}}$$
$$t_{\frac{1}{2}} = \frac{u \sin\theta}{9.8}$$
$$t = \frac{2u \sin\theta}{9.8}$$

$$s_h = v_h t = u_h t$$
$$s_h = u \cos\theta \times \frac{2u \sin\theta}{9.8}$$
$$\frac{u^2 \times 2 \sin\theta \cos\theta}{9.8} = 250$$
$$\frac{3600}{9.8} \times \sin 2\theta = \frac{49}{72}$$
$$2\theta = 42.8\ ...^\circ, 137.1\ ...^\circ$$
$$\boldsymbol{\theta = 21^\circ, 69^\circ}$$

Question 24

a) The circumference of each orbital is equal to a whole number multiple of the electrons' de Broglie wavelength – ie. $n\lambda$. Circumference is equal to $2\pi r$.

$$n\lambda = 2\pi r$$
$$n\frac{h}{mv} = 2\pi r$$
$$r = \frac{nh}{2\pi mv}$$

b) 2 marks: experimental evidence
   - Davisson and Germer observed that electrons scattered off nickel crystals exhibited a diffraction pattern
   - Diffraction is a wave property, so the electrons were behaving as waves

   2 marks: limitation of Bohr model
   - Bohr's model could not explain *why* its quantised orbits were stable, it only postulated that they are stable
   - By de Broglie's contribution, each orbit has the right circumference for the electrons to form a standing wave
   - The standing wave exists in a stable state and emits no energy, explaining why the orbits are stable

Question 25

a) Answers should include a combination of:

- As each coin rolls down the track, it experiences a change in magnetic flux.
- This induces an EMF in the conductive coins as per Lenz's Law ($\varepsilon = N\frac{\Delta\phi}{\Delta t}$). As they are of equal mass, and have equal velocity prior to entering the magnetic field, their change in flux over time will be the same, thus each coin will experience an equal induced EMF.
- However, as the resistance of the coins differs, the magnitude of the current resulting from the EMF will differ. Using Ohm's Law (*V=IR)*, the current induced in the copper coin will be greater than that induced in the aluminium coin, because copper has less resistance.
- The currents induced have an associated magnetic field that interacts with the external magnetic field to exert a force upon the coin. This force acts in a direction that opposes the change that caused it – the coin was accelerating from A to B, so it experiences a retarding force towards A.
- Because the current in the copper coin was greater than the aluminium coin, the force on it is greater, so it slows more.
- Therefore, the recorded stopwatch time for copper is greater than aluminium.

b)

Force from the magnet on the wire:

$$F_B = BIl = 0.5 \times 2 \times 0.02$$
$$F_B = 0.02 \text{ N upwards}$$

Reaction force on the magnet = 0.02 N downwards

$$W = mg = 0.2 \times 9.8$$
$$W = 1.96 \text{ N downwards}$$

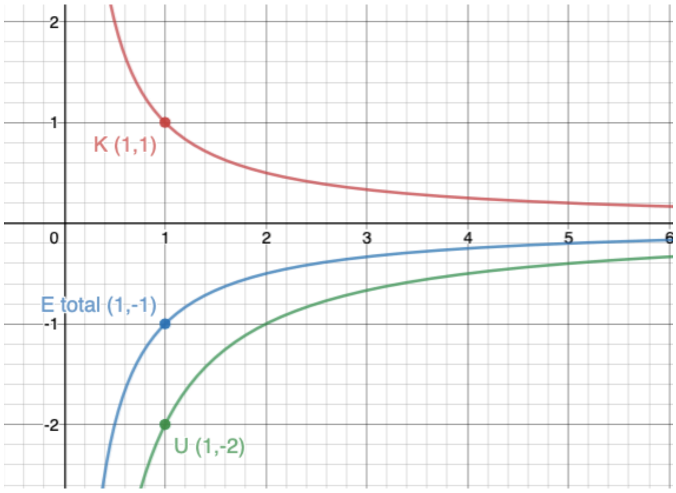
$$F_{\text{net}} = W + F_B = 1.98\ N$$
$$m = \frac{F_{net}}{g}$$
$$\boldsymbol{m = 202\ \text{g}}$$

c)

$$\text{KE} = \Delta\text{GPE}$$
$$\frac{1}{2}mv^2 = mg\Delta h$$
$$\Delta h = \frac{v^2}{2g}$$
$$\Delta h = \frac{0.23^2}{2 \times 9.8} = \mathbf{2.7\ mm}$$

Question 26

a)



b)

$$M = 6.0 \times 10^{24} \text{ kg}$$
$$m = 300 \text{ kg}$$
$$r_i = 100 \times 10^3 + 6.371 \times 10^6 \text{ m}$$
$$r_f = 200 \times 10^3 + 6.371 \times 10^6 \text{ m}$$

$$\Delta\text{GPE} = \text{GPE}_f - \text{GPE}_i$$
$$\Delta\text{GPE} = -\frac{GMm}{r_f} - \left(-\frac{GMm}{r_i}\right)$$
$$\Delta\text{GPE} = \mathbf{2.8 \times 10^8} \textbf{ J increase}$$

Question 27

$$E = \frac{V}{d} = 1 \times 10^{-3} \text{ V m}^{-1}$$

$$ma_E = qE$$
$$a_E = \frac{qE}{m} = \frac{1.602 \times 10^{-19} \times 1 \times 10^{-3}}{1.673 \times 10^{-27}}$$
$$= 95756.1 \ldots \text{ m s}^{-2}$$

$$a = a_E + g = 95765.9 \ldots \text{ m s}^{-2}$$

$$u_v = \sin 30 \text{ m s}^{-1}, \ u_H = \cos 30 \text{ m s}^{-1}$$
$t_{\frac{1}{2}}$ is where $v_v = 0$
$$v_v = u_v + at_{\frac{1}{2}}$$
$$95765.9t_{\frac{1}{2}} = \sin 30$$

$$t_{\frac{1}{2}} = 5.2 \ldots \times 10^{-6} \ s$$
$$t = 10.4 \ldots \times 10^{-6} \text{ s}$$
$$s_H = u_H t = \cos 30 \times 10.4 \ldots \times 10^{-6}$$
$$\textbf{range} = \mathbf{9 \times 10^{-6}} \textbf{ m}$$

Question 28

$$v_{\text{escape}} = 3 \times 10^8 \text{ m s}^{-1}$$
$$\sqrt{\frac{2GM}{r}} = 3 \times 10^8$$
$$\sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 10^{50}}{r}} = 3 \times 10^8$$
$$r = 1.5 \times 10^{23} \text{ m}$$

Question 29

for half a period, $\Delta\Phi = 1$ Wb

$$\Delta t = \frac{1}{2} \times T = \frac{1}{2} \times \frac{1}{f} = \frac{1}{100}\text{ s}$$

$$\frac{\Delta\Phi}{\Delta t} = 100\text{ Wb s}^{-1}$$

$$V_p = N\frac{\Delta\Phi}{\Delta t}$$

$$V_p = 10\,000\text{ V}$$

$$V_{\text{out}} = V_p \times \frac{N_{\text{out}}}{N_p}$$

$$V_{\text{out}} = 10\,000 \times 2 = \mathbf{20\,000\ V}$$

Question 30
Transformers, generators, motors, power line transmission.

Question 31
For level flight, the net torque must be zero so no rotation occurs. Only the vertical component of the 1000 N force needs to be considered, as the horizontal component acts through the centre of mass.

$$\tau_{\text{clockwise}} = \tau_{\text{anticlockwise}}$$

$$1000 \cos 10 \times 1.2 = F \times 1$$

$$F = 1000 \cos 10 \times 1.2 = 985\text{ N}$$

Question 32

a) Strange and antidown

b) $F = \frac{mv^2}{r}, F = qvB, F = qE$

Limitation: they have no charge so they don't experience a force in magnetic field

c) 2.35×10^{-8} s

Question 33
Oscillating charged particles constitute a current, which generates a changing magnetic field. This changing magnetic field creates a changing electric field that is at right angles to the magnetic field. The electric field then creates a magnetic field, and so on, such that the two fields continue to propagate the wave through space.

Question 34
Discuss experiments from 7.2 and 7.3 in particular, evaluate ("to what extent" = judgement) how they influenced understanding.