LMC Lachlan Macquarie College

Physics

Trial Higher School Certificate Examination

2019

General Instructions	• Reading Time – 5 minutes • Working Time – 3 hours • Write using black pen • Draw diagrams using pencil • NESA approved calculators may be used
Total Marks	**Section I – 20 marks (pages 3 – 7)** • Attempt questions 1 – 20 • Allow about 35 minutes for this section **Section II – 80 marks (pages 8 – 18)** • Attempt questions 21 – 37 • Allow about 2 hours and 35 minutes for this section

Section I – Multiple Choice

20 marks (1 mark each)

Please answer on the answer sheet provided.

1. The relationship between Centripetal Force and the Radius of Curvature is:

   a) Proportional
   b) Inversely Proportional
   c) Exponential
   d) Longitudinal

2. Four identical pieces of wire are bent to form four coils, each containing a different number of loops. Each coil carries 4.0 A of current and is placed in the same magnetic field of 0.2 T. Which of the four coils would experience the greatest torque?

   a) 1 loop, area of coil 0.18 m^2
   b) 2 loops, area of coil 0.045 m^2
   c) 3 loops, area of coil 0.020 m^2
   d) 4 loops, area of coil 0.011 m^2

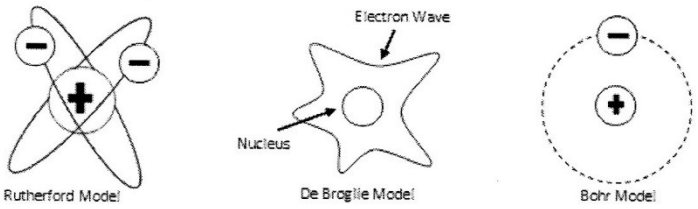
3. Calculate the wavelength of a ray of light passing through two slits 5 μm apart and creating a diffraction pattern with 20^0 between the central point and first maxima.

   a) 0.17 m
   b) 170 nm
   c) 1.7 μm
   d) 17 cm

4. The mass of a proton is 1.673×10^{-27} kg. The mass of a neutron is 1.675×10^{-27} kg. A Helium nucleus, made of 2 protons and 2 neutrons, has a mass of 6.646×10^{-27} kg. Calculate the energy associated with the mass deficiency between the nucleus and its individual components.

   a) 9.36×10^{-2} eV
   b) 28.1 MeV
   c) 3.76 GeV
   d) 4.5×10^{-11} eV

5. The model of the atom has been changed over the course of history. Some key models are illustrated below.



The order of historical development of these models from oldest to youngest is:

a) Rutherford > De Broglie > Bohr
b) Rutherford > Bohr > De Broglie
c) De Broglie > Bohr > Rutherford
d) De Broglie > Rutherford > Bohr

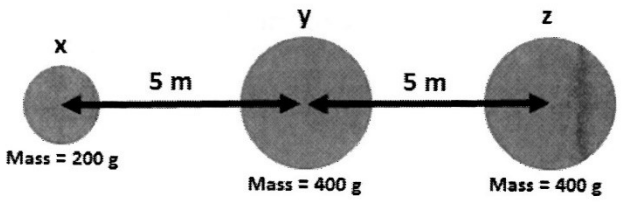
6. The table summarises the charge associated with different quarks.

Quark Flavour	Charge (relative to electron)
Up	$+\frac{2}{3}$
Down	$-\frac{1}{3}$

Based on this table, the quark composition of a Proton must be?

a) 2 Up Quarks and 1 Down Quark
b) 1 Up Quark and 2 Down Quarks
c) 3 Up Quarks
d) 3 Down Quarks

7. Consider the three objects on the following diagram.



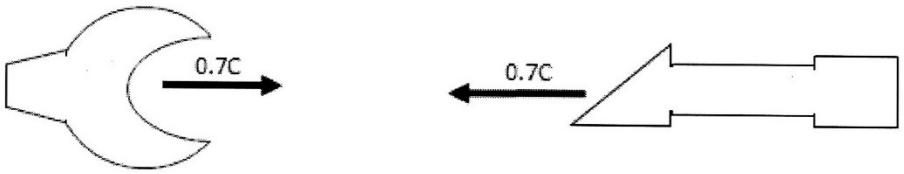
What is the ratio of the gravitational forces from x and z on y (i.e. Fxy:Fzy)?

a) 1:1
b) 1:2
c) 1:3
d) 1:4

8. Two 20 cm long parallel wires carry currents of 3 A and 4 A respectively. Calculate the force on the wires if the currents are travelling in the same direction and the wires are positioned 5 cm apart.

a) 9.6×10^{-6} N Attraction
b) 9.6×10^{-6} N Repulsion
c) 2.4×10^{8} N Attraction
d) 2.4×10^{8} N Repulsion

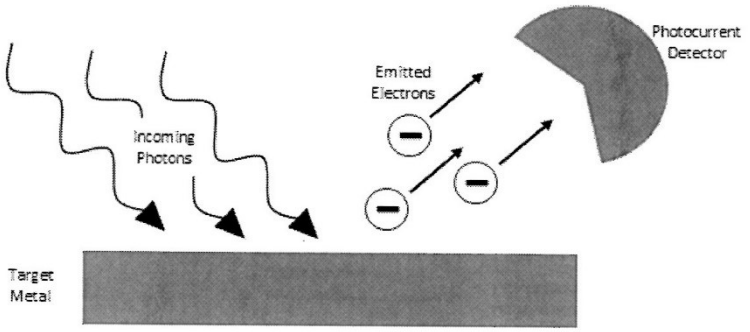
9. Two space ships are traveling towards each other, each at 0.7C, as per the diagram below:



If Ship A sent a radio message to Ship B, the velocity of the radio wave when it reaches Ship B would be?

a) C
b) 1.4C
c) 1.7C
d) 2.4C

10. The following experiment is set up to demonstrate the photoelectric effect:



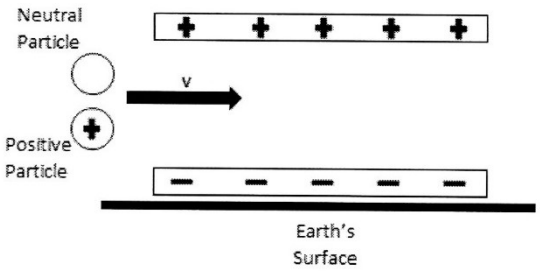
The effect on the photocurrent as the intensity of light increases will be an increase in:

a) Photon Energy.
b) Photon Wavelength.
c) Electron kinetic energy.
d) Photocurrent magnitude.

11. A key feature of Millikan's Oil Drop Experiment which ensures scientific reliability is:

a) Controlling all variables except the independent and dependent.
b) Comparing his results with the known charge of an electron.
c) Thousands of repetitions with consistent results.
d) Using a control trial with water instead of oil.

12. A positively charged particle and a neutral particle are accelerated into a vertically orientated electric field as per the diagram:



Compare their trajectories after taking into account influences from electric and gravitational fields.

	Neutral Particle	*Positive*
a)	Downward Trajectory	Downward Trajectory
b)	Continues Straight	Downward Trajectory
c)	Upward Trajectory	Upward Trajectory
d)	Continues Straight	Upward Trajectory

13. The equation which best represents alpha decay is?

a) $^{233}_{92}U \rightarrow {}^{229}_{90}Th + {}^{4}_{2}He$

b) $^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + {}^{0}_{0}\overline{v}$

c) $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$

d) $^{4}_{2}He + {}^{4}_{2}He \rightarrow {}^{8}_{4}Be + \gamma$

14. The Rosetta Probe, mass m kg, orbits comet 67P of mass M kg with an orbital period of 5T. Philae, the Probe's landing module, mass 1/2m kg, orbits the same comet with an orbital period of T.

The ratio of the orbital radii of the two machines is closest to:

a) 1:1
b) 2:1
c) 3:1
d) 4:1

15. The gravitational field strength for an object of M = 5.972×10^{24} kg and r = 6371 km is equal to?

a) 6.25×10^{10} m/s^2
b) 6.25×10^{7} m/s^2
c) 9.81×10^{6} m/s^2
d) 9.81 m/s^2

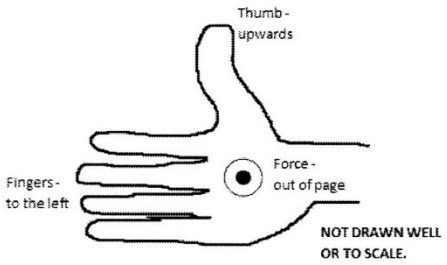
16. An object's gravitational potential energy is tripled. Assuming all other variables are constant, this gain in energy is accompanied by a change in radius equivalent to:

a) Tripling the radius.
b) Reducing the radius by a third.
c) Doubling the radius.
d) Halving the radius.

17. A transformer has an input coil with 250 turns and an output coil with 1000 turns.
Which choice shows possible correct values for this transformer?

	Input	*Output*
a)	240 V, 10 A	48 V, 50 A
b)	500 V, 200 A	2000 V, 50 A
c)	1200 V, 4 A	240 V, 20 A
d)	240 V, 10 A	960 V, 2.5 A

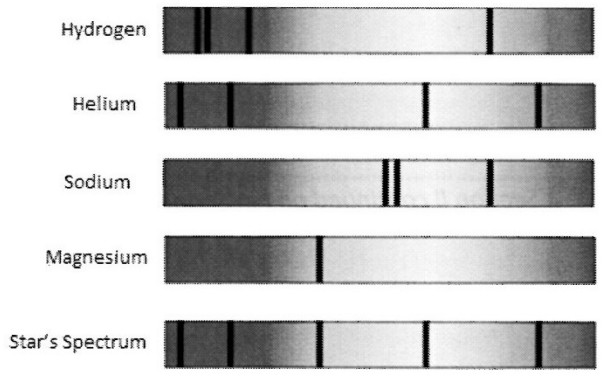
18. A Student uses the right hand push rule to determine the force on a proton as it moves through a magnetic field. The student orientates their hand as per the diagram below:



This hand orientation shows that the position of the North Pole of the magnetic field would be:

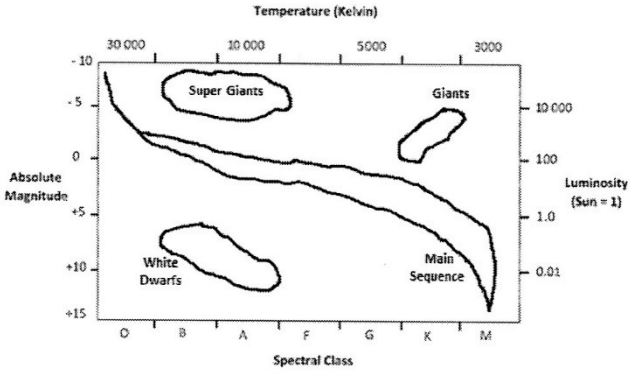
a) Upwards at the top of the page.
b) Downwards at the bottom of the page.
c) To the right of the page.
d) To the left of the page.

19. Use the absorption spectra provided to determine the composition of a star.



a) Hydrogen and Sodium
b) Helium and Sodium
c) Magnesium and Sodium
d) Helium and Magnesium

20. A star has the following properties: Spectral Class A, Temperature 10 000 Kelvin, Absolute Magnitude of +10, Luminosity 0.01.



Based on the Hertzsprung-Russel Diagram above, the star is a:

a) Super Giant
b) Giant
c) White Dwarf
d) Main Sequence

End of Section I

Section II continued on next page

Section II – Written Responses
80 marks (2 – 9 marks

Please answer in the spaces provided.

Question 21 (8 marks)

The striker of a national women's soccer team is given a penalty kick with 10 seconds left on the clock. The teams are currently drawn 1 all. The striker takes her shot from the penalty spot 11 m directly from the centre of the goal. She aims for the top left corner of the goal which is 3.6 m to her left and 2.4 m off the ground. She kicks the ball and it reaches the goal 500 milliseconds later.

a) Draw a diagram of this scenario **(1)**

b) Calculate the range of the shot. **(2)**

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c) Does the ball reach the top corner? Justify your answer mathematically. **(3)**

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d) Given that the ball's initial y-velocity is 6.86 m/s, what is the ball's initial velocity? **(2)**

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Question 22 (2 marks)

In practice, projectiles rarely travel their theoretical maximum ranges and heights even when given the correct initial velocity. Account for the difference between the theoretical and practical scenarios.

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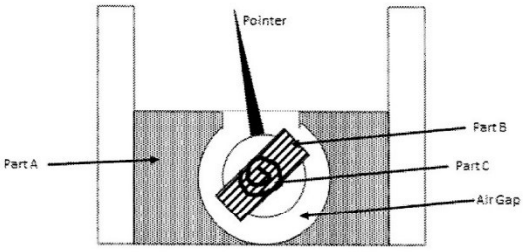
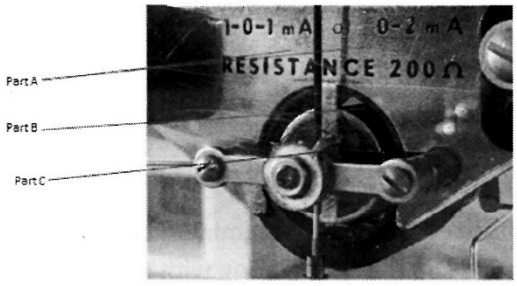
Question 23 (6 marks)

Construct a flow chart that could be used to differentiate between electrons, protons and neutrons. Include information regarding their major features: mass, reaction to electric fields and reaction to magnetic fields.

Question 24 (5 marks)

Many simple multimeters use the movement of a coil within a permanent magnet. These multimeters are used in school laboratories. A diagram and photographs of the motor, which uses a milliampere current, are provided below.





Use your knowledge of physics, especially DC electrical motors, to explain the function of Parts A, B and C in producing a deflection of the needle, which allows the reading to be shown on a scale with evenly spaced units.

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Question 25 (5 marks)

Explain the principal of Relativity of Simultaneity. In your answer refer to one thought experiment you have studied. Include a diagram to support your answer.

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Question 26 (3 marks)

Newton famously explored the concept of Escape Velocity by suggesting a cannonball fired from a high mountain would remain in orbit if its kinetic energy was equivalent to its gravitational potential energy. Derive an equation for Escape Velocity using equations you have studied during the HSC.

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Question 27 (3 marks)

A magnet dropped through an Aluminium pipe falls slower than one that is dropped through a plastic pipe. Explain this observation with reference to any relevant physical principals.

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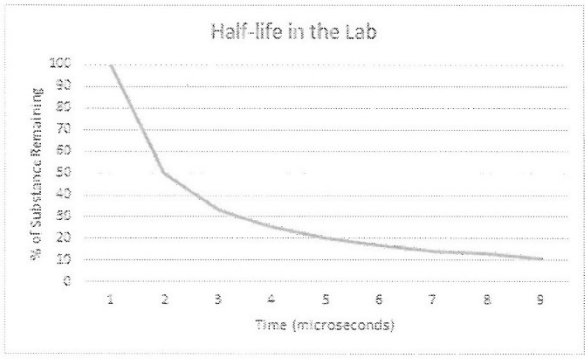
Question 28 (4 marks)

The half-life of radioactive particles from a substance is measured in the lab. The results of the measurement are displayed in the graph below:



DRAWN TO SCALE

a) Using the graph, determine the half-life of this type of particle. **(1)**

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b) The particles in question are usually found moving through space at 0.6C. Calculate the half-life of the particle taking into account relativistic effects. **(3)**

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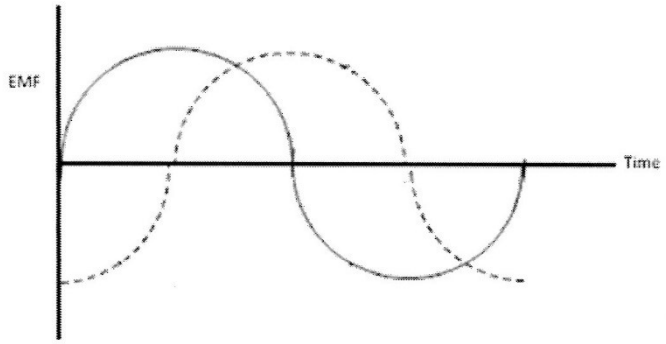
Question 29 (3 marks)

Draw a labelled diagram of the conducting loop and commutator associated with the output below:



Question 30 (6 marks)

A hand held spectroscope was used to observe and analyse incandescent and fluorescent light. Using the graphs below showing the profiles for incandescent and fluorescent light sources, describe how spectroscopy can be used to analyse these light sources. State limitations in quantitative analysis using the hand held spectroscope.

Figure 1: Incandescent Light

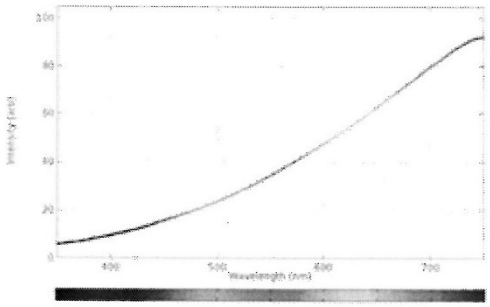
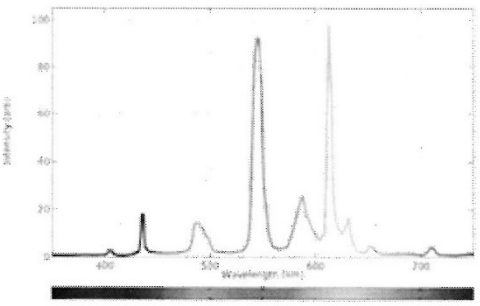


Figure 2: Fluorescent Light



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Question 31 (5 marks)

In terms of Lenz's Law, explain the relationship between the relative motion of a magnet and a solenoid with a specific focus on the polarities of the magnet and solenoid. Use labelled diagrams to support your answer.

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Question 32 (3 marks)

Consider Bohr's model of the atom in relation to the Rydberg Equation: $\frac{1}{\lambda} = R[\frac{1}{n_f^2} - \frac{1}{n_i^2}]$.

a) Calculate the wavelength of an electron transitioning from the 5th to the 3rd orbital. **(2)**

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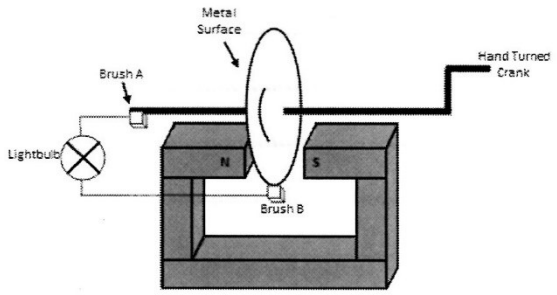
a) Draw a labelled diagram to illustrate your response to 'a)' **(1)**

Question 33 (9 marks)

Analyse how the work of Planck, Bohr and de Broglie led to the development of quantum physics.

Question 34 (4 marks)

Explain how the simple generator, pictured below, allows for the flow of DC current.



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Question 35 (3 marks)

Select, outline and assess one piece of evidence you have studied which supports the Big Bang Theory.

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Question 36 (7 marks)

Photoelectric effect data using sodium is given below.

Light (photon) frequency (x 10-14 Hz)	Electron kinetic energy (eV)
5.6	0.01
6.0	0.18
6.5	0.41
7.1	0.70
7.9	0.97
8.8	1.31

a) Use this data to derive a value for Planck's constant 'h' and the work function for sodium metal. **(3)**

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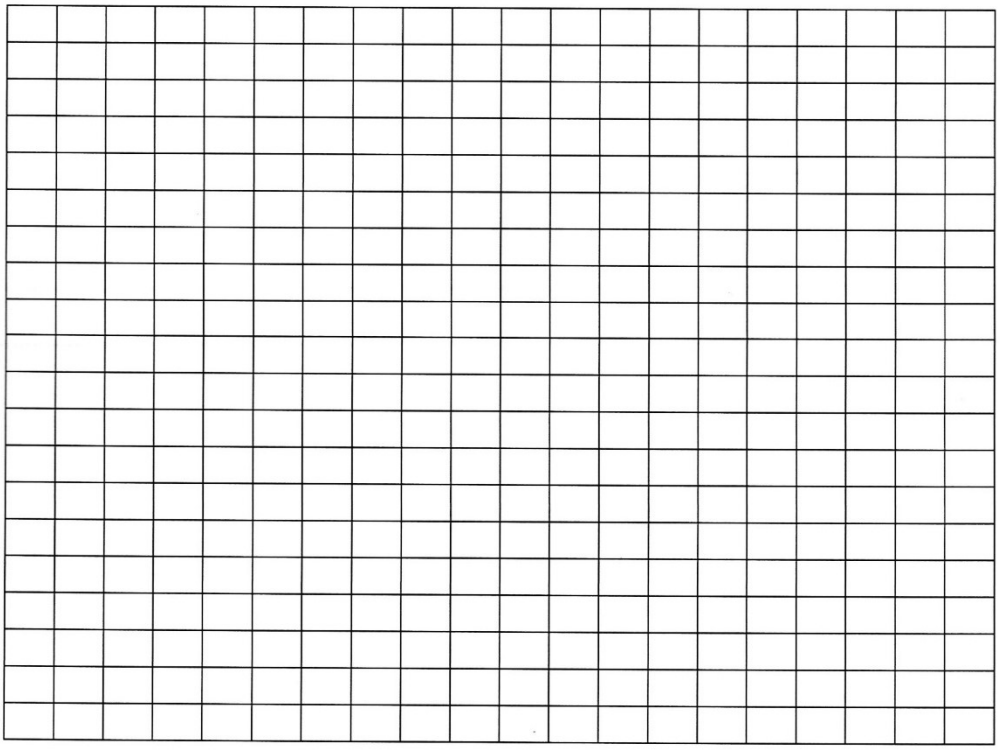

b) E/M Radiation with a wavelength of 300 nm hits the surface of a metal with a work function of 4.33 eV. What is the maximum speed of the electrons which will be ejected in this scenario? **(4)**

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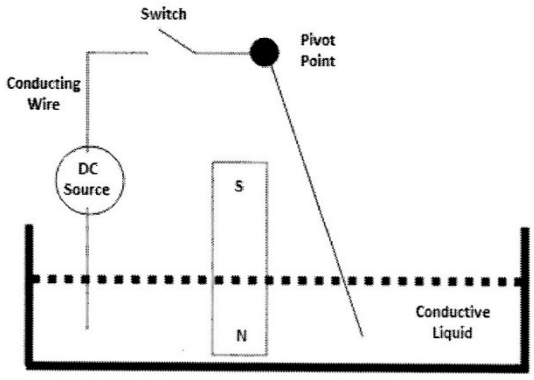
Question 37 (4 marks)

The diagram below represents a 'Faraday Motor'. When the switch is closed the wire will rotate about the magnet. Compare this rotation to uniform circular motion.



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End of Examination

Acknowledgements:
Mr Adam Talut (Acting Head Teacher Science – Greystanes HS)
Mrs Deborah James (Science Teacher: Normanhurst Boys HS))

LMC Lachlan Macquarie College

PHYSICS HSC TRIAL ANSWERS

SECTION I – 20 marks

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

SECTION II – 80 marks

21 A

Criteria	Marks
• Draws a diagram depicting the scenario	1

21 B

Criteria	Marks
• Correctly calculates the range using Pythagoras' Theorem.	2
• Uses Pythagoras's Theorem but calculates incorrect value.	1

21 C

Criteria	Marks
• Concludes that the ball DOESN'T reach the top corner by recognising Δy_{max} occurs at $v_y = 0$ and shows this mathematically.	3
• Makes a conclusion and justifies it mathematically.	2
• Makes a conclusion OR attempts to justify problem with SUVAT equations.	1

21 D

Criteria	Marks
• Correctly calculates the initial velocity including magnitude and angle.	2
• Correctly calculates the magnitude OR angle of the initial velocity.	1

22

Criteria	Marks
• States that theoretical calculations assume constant u_x AND constant g AND • Accounts for horizontal AND vertical air friction during practical scenarios causing a discrepancy in results from theoretical calculations	2
• States theoretical calculations assume constant horizontal velocity OR vertical acceleration OR • States that air friction causes discrepancy in theoretical calculations	1

23

Criteria	Marks
• Constructs a detailed flow chart, including all major features of the particles, that can differentiate between each particle.	6
• Constructs a flow chart, including two features of the particles, that can differentiate between each particle.	5
• Constructs a flow chart, including one feature of the particles, that can differentiate between each particle.	4
• Constructs a flow chart AND provides all relevant information.	3
• Constructs a flow chart AND provides some relevant information	2
• Constructs a flow chart OR provides some relevant information.	1

24

Criteria	Marks
• Highly detailed explanation including: o part of the motor represented by each A (permanent magnet), B (rotor, moving coil) and C (restoring spring); AND o curved permanent magnet (A) producing radial magnetic field allowing evenly spaced units; AND o role of A (magnetic field), B (current carrying conductor coils) and C (restoring pointer to zero when no current flows) in relation to the deflection of the pointer; AND o all of the above linked to the motor effect	5
• Detailed explanation including: o Identify of all parts and their roles; AND linked to deflection of pointer and the motor effect OR o Identify of all parts AND roles of A and B AND radial magnetic field; linked to deflection of pointer and the motor effect	4
• Detailed explanation including: o Identity and roles of parts A and B; linked to deflection and the motor effect	3
• Explanation including: o Identify and roles of parts A and B; linked to the deflection of the pointer	2
• Provides some relevant information	1

25

Criteria	Marks
• Highly detailed explanation supported with clear, contextual diagram.	5
• Detailed explanation supported with clear, contextual diagram. OR • Highly detailed explanation WITHOUT clear, contextual diagram.	4
• Detailed explanation supported with a contextual diagram. OR • Detailed explanation WITHOUT diagram.	3
• Provides some relevant information AND includes a diagram.	2
• Provides some relevant information OR includes a contextual diagram.	1

26

Criteria	Marks
• Correctly derives Escape Velocity equation by equating Kinetic and Gravitational Potential Energy.	3
• Attempts to derive Escape Velocity equation by equating Kinetic and Gravitational Potential Energy.	2
• Provides some relevant information.	1

27

Criteria	Marks
• Highly detailed explanation	3
• Detailed explanation	2
• Provides some relevant information.	1

28 A

Criteria	Marks
• Correctly determines half-life from graph.	1

28 B

Criteria	Marks
• Correctly determines particle's relativistic half-life using time dilation equation.	3
• Attempts to determine particle's relativistic half-life using time dilation equation.	2
• Provides some relevant information.	1

29

Criteria	Marks
• Correctly draws a slip ring commutator with 2 perpendicular conducting loops.	3
• Attempts to draw a slip ring commutator with 2 perpendicular conducting loops.	2
• Attempts to draw a slip ring commutator OR 2 perpendicular conducting loops.	1

30

Criteria	Marks
• Highly detailed description of the use of a school hand held spectroscope including: o Description of wavelengths shown when viewing incandescent light AND fluorescent light AND linking these to the quantitative data shown on the horizontal axes of figures 1 and 2 respectively o Description of observations during spectroscopy experiments AND stating that intensity of light not quantitatively measured with school spectroscope as a limitation AND linking this to the detail provided on the vertical axes of figures 1 and 2 respectively	6
• Detailed description including: o Description of wavelengths shown when viewing incandescent light AND fluorescent light AND linking these to the quantitative data shown on the horizontal axes of figures 1 and 2 respectively o Description of observations during spectroscopy experiments AND stating that intensity of light not quantitatively measured with school spectroscope as a limitation	5
• Detailed description including: o Description of wavelengths shown when viewing incandescent light AND fluorescent light AND linking these to the horizontal axes of figures 1 and 2 respectively o Description of observations during spectroscopy experiments AND stating that intensity of light not quantitatively measured with school spectroscope as a limitation	4
• Detailed description including: o Description of wavelengths shown when viewing incandescent light AND fluorescent light AND linking these to figures 1 and 2 respectively o Stating that intensity of light not quantitatively measured with school spectroscope as a limitation	3
• Description including: o Wavelengths shown when viewing incandescent light AND fluorescent light AND linking these to figures 1 and 2 respectively OR o Wavelengths when viewing incandescent and fluorescent light AND stating that intensity of light not quantitatively measured with school spectroscope as a limitation	2
• Provides some relevant information	1

31

Criteria	Marks
• Highly detailed explanation supported with clear, contextual diagram.	5
• Detailed explanation supported with clear, contextual diagram. OR • Highly detailed explanation WITHOUT clear, contextual diagram.	4
• Detailed explanation supported with a contextual diagram. OR • Detailed explanation WITHOUT diagram.	3
• Provides some relevant information AND includes a diagram.	2
• Provides some relevant information.	1

32 A

Criteria	Marks
• Correctly calculates the wavelength of the electron showing full working and providing correct units	2
• Correctly calculates the wavelength of the electron, incorrect units OR • Calculates the wavelength of the electron showing full working, one error	1

32 B

Criteria	Marks
• A labelled diagram of Bohr's model showing the electron transition from the 5th to 3rd orbital	1

33

Criteria	Marks
• Shows a comprehensive understanding of how the progressive work of Planck, Bohr and de Broglie sequentially led to the development of quantum physics • Clearly relates how the contributions of each scientist are related (Bohr incorporated Planck's ideas, de Broglie incorporated Planck's work)	9
• Shows a sound understanding of the progressive work in relation to the development of quantum physics • Relates contributions of each scientist in sequence	7-8
• Outlines the progressive work towards the development of quantum physics • Relates contributions of each scientist	5-6
• Outlines some progressive work • Relates contributions of at least two scientists	3-4
• Provides some relevant information	1-2

34

Criteria	Marks
• Highly detailed explanation including: o Induction of eddy currents in the region of magnetic field o Account for Lenz's law and link to direction of induced current o Link direction of mechanical energy to allow for DC current flow o Link slip ring commutator to DC current	4
• Detailed explanation including: o Induction of eddy currents o Account for Lenz's law o Link slip ring commutator OR • Detailed explanation including: o Induction of eddy currents o Account for Lenz's law o Applied mechanical energy to allow for DC current	3
• Explanation which links induction of eddy currents to DC current	2
• Provides some relevant information	1

35

Criteria	Marks
• Highly detailed outline and assessment of selected evidence for the Big Bang.	3
• Detailed outline and assessment of selected evidence for the Big Bang.	2
• Provides some relevant information.	1

36 A

Criteria	Marks
• Correct graphing of data (linear relationship) with frequency on x-axis; AND • Correct calculation of gradient (identified as Planck's constant 'h') shown; AND • Work function for sodium metal indicated on graph as extrapolation of line back to vertical axis	3
• Correct graphing of data (linear relationship) with frequency on x-axis; AND • Correct calculation of gradient (identified as Planck's constant 'h') shown; OR work function for sodium metal indicated on graph as extrapolation of line back to vertical axis	2
• Data is graphed	1

36 B

Criteria	Marks
• Correct answer with full working shown	4
• Correct working fully shown, including correct frequency calculated, one error	3
• Working shown, including correct frequency calculated, two errors	2
• Relevant working shown	1

37

Criteria	Marks
• Highly detailed comparison between the rotation of the Faraday Motor and circular motion including: o Description of how the structures of the Faraday motor work when current flows through the wire and how the motor effect is applied to allow rotation of the wire AND o Similarities to the direction of motion of wire in uniform B field and to uniform circular motion	4
• Detailed comparison including most of the elements above addressing both application of the motor effect the Faraday motor AND uniform circular motion	3
• Description of how the wire goes through circular motion	2
• Provides some relevant information	1