QCE Physics Units 3&4

Paper 1

Student's Name: _____

Teacher's Name: _____

Time allowed
- Perusal time – 10 minutes
- Working time – 90 minutes

General instructions
- Answer all questions in this question and response booklet.
- QCAA-approved calculator permitted.
- QCAA formula sheet provided.
- Planning paper will not be marked.

Section 1 (20 marks)
- 20 multiple choice questions

Section 2 (25 marks)
- 7 short response questions

SECTION 1

Instructions

• Choose the best answer for Questions 1–20.

• This section has 20 questions and is worth 20 marks.

• Use a 2B pencil to fill in the A, B, C or D answer bubble completely.

• If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	**B**	**C**	**D**
Example:	●	○	○	○

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

SECTION 2

Instructions

- Write using black or blue pen.
- Respond in paragraphs consisting of full sentences.
- If you need more space for a response, use the additional pages at the back of this booklet.
    – On the additional pages, write the question number you are responding to.
    – Cancel any incorrect response by ruling a single diagonal line through your work.
    – Write the page number of your alternative/additional response, i.e. See page …
    – If you do not do this, your original response will be marked.
- This section has seven questions and is worth 25 marks.

QUESTION 21   (2 marks)

Define the term *meson* and identify what mesons consist of.

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QUESTION 22   (3 marks)

Thomson (1904) and Rutherford (1911) both proposed models of the atom.

Compare Thomson and Rutherford's models of the atom and explain the evidence that pointed to one model replacing the other as the preferred model of the atom.

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QUESTION 23 (3 marks)

Consider the proton, electron and neutron.

Which one of the particles above was last to be discovered? Explain your answer.

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QUESTION 24   (8 marks)

One observation of the photoelectric effect that could not be explained by the wave model of light was 'no time delay'.

Outline two other observations associated with the photoelectric effect that cannot be accounted for by the wave model of light. Explain how the observations support the particle model of light and identify the observation that the wave model would have predicted.

Observation 1 _____

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Observation 2 _____

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QUESTION 25   (2 marks)

Explain the concept of relativity of simultaneity.

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QUESTION 26   (4 marks)

Explain how the formation of bright and dark bands in Young's double slit experiment supports
the wave model of light.

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QUESTION 27 (3 marks)

Beth is riding down a slope at an angle of 25.0°, as shown in the diagram below. The combined mass of Beth, her ski gear and her skis is 100.0 kg. The force of friction acting up the slope is 140.0 N
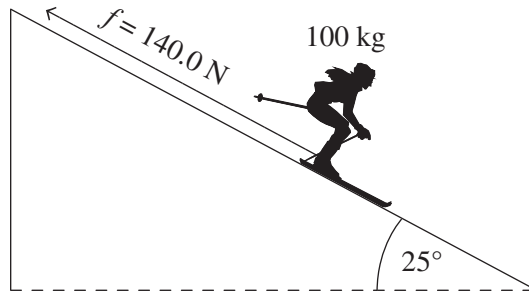
Calculate the magnitude of Beth's acceleration down the slope. Show your working.

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Magnitude of acceleration =_____ m s^{-2} (to 1 decimal place)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

Neap

Trial Examination 2020

QCE Physics Units 3&4

FORMULAS

Processing of data
Percentage uncertainty (%) = $\dfrac{\text{absolute uncertainty}}{\text{measurement}} \times 100$
Percentage error (%) = $\left\lvert \dfrac{\text{measured value} - \text{true value}}{\text{true value}} \right\rvert \times 100$

Heating processes	
$T_K = T_C + 273$	$Q = mL$
$Q = mc\Delta T$	$\Delta U = Q + W$
$\eta = \dfrac{\text{energy output}}{\text{energy input}} \times \dfrac{100}{1}\%$	

Ionising radiation and nuclear reactions	
$N = N_0\left(\dfrac{1}{2}\right)^n$	$\Delta E = \Delta mc^2$

Electrical circuits	
$I = \dfrac{q}{t}$	$P = I^2 R$
$V = \dfrac{W}{q}$	$V_t = V_1 + V_2 + \ldots V_n$
$P = \dfrac{W}{t}$	$R_t = R_1 + R_2 + \ldots R_n$
$R = \dfrac{V}{I}$	$I_t = I_1 + I_2 + \ldots I_n$
$P = VI$	$\dfrac{1}{R_t} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots \dfrac{1}{R_n}$

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Linear motion and force	
$v = u + at$	$W = \Delta E$
$s = ut + \dfrac{1}{2}at^2$	$W = Fs$
$v^2 = u^2 + 2as$	$E_k = \dfrac{1}{2}mv^2$
$a = \dfrac{F_{net}}{m}$	$\Delta E_p = mg\Delta h$
$p = mv$	$\sum \dfrac{1}{2}mv^2_{before} = \sum \dfrac{1}{2}mv^2_{after}$
$\sum mv_{before} = \sum mv_{after}$	

Waves	
$v = f\lambda$	$L = (2n - 1)\dfrac{\lambda}{4}$
$f = \dfrac{1}{T}$	$\dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2} = \dfrac{n_2}{n_1}$
$L = n\dfrac{\lambda}{2}$	$I \propto \dfrac{1}{r^2}$

Gravity and motion	
$v_y = gt + u_y$	$v = \dfrac{2\pi r}{T}$
$s_y = \dfrac{1}{2}gt^2 + u_y t$	$a_C = \dfrac{v^2}{r}$
$v_y^2 = 2gs_y + u_y^2$	$F_{net} = \dfrac{mv^2}{r}$
$v_x = u_x$	$F = \dfrac{GMm}{r^2}$
$s_x = u_x t$	$g = \dfrac{F}{m} = \dfrac{GM}{r^2}$
$F_g = mg$	$\dfrac{T^2}{r^3} = \dfrac{4\pi^2}{GM}$

Electromagnetism

$F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Qq}{r^2}$	$F = qvB\sin\theta$
$E = \dfrac{F}{q} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$	$\phi = BA\cos\theta$
$V = \dfrac{\Delta U}{q}$	$\text{emf} = -\dfrac{n\Delta(BA_\perp)}{\Delta t}$
$B = \dfrac{\mu_0 I}{2\pi r}$	$\text{emf} = -n\dfrac{\Delta\phi}{\Delta t}$
$B = \mu_0 nI$	$I_p V_p = I_s V_s$
$F = BIL\sin\theta$	$\dfrac{V_p}{V_s} = \dfrac{n_p}{n_s}$

Special relativity

$t = \dfrac{t_0}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}$	$p_v = \dfrac{m_0 v}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}$
$L = L_0\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}$	$\Delta E = \Delta mc^2$

Quantum theory

$\lambda_{\max} = \dfrac{b}{T}$	$\lambda = \dfrac{h}{p}$
$E = hf$	$n\lambda = 2\pi r$
$E_k = hf - W$	$mvr = \dfrac{nh}{2\pi}$
$\dfrac{1}{\lambda} = R\left(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right)$	

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PHYSICAL CONSTANTS AND UNIT CONVERSIONS

Heating processes	
Latent heat of fusion for water	$L_f = 3.34 \times 10^5$ J kg^{-1}
Latent heat of vaporisation for water	$L_v = 2.26 \times 10^6$ J kg^{-1}
Specific heat capacity of ice	$c_i = 2.05 \times 10^3$ J kg^{-1} K^{-1}
Specific heat capacity of steam	$c_s = 2.00 \times 10^3$ J kg^{-1} K^{-1}
Specific heat capacity of water	$c_w = 4.18 \times 10^3$ J kg^{-1} K^{-1}

Ionising radiation and nuclear reactions	
Atomic mass unit	1 amu = 1.66×10^{-27} kg
Electron volt	1 eV = 1.60×10^{-19} J
Mass of an alpha particle	$m_\alpha = 6.6446572 \times 10^{-27}$ kg
Mass of an electron	$m_e = 9.1093835 \times 10^{-31}$ kg
Mass of a neutron	$m_n = 1.6749275 \times 10^{-27}$ kg
Mass of a proton	$m_p = 1.6726219 \times 10^{-27}$ kg
Speed of light in a vacuum	$c = 3 \times 10^8$ m s^{-1}

Electrical circuits	
Charge on an electron	$e = -1.60 \times 10^{-19}$ C

Linear motion and force	
Mean acceleration due to gravity on Earth	$g = 9.8$ m s^{-2}

Waves	
Speed of sound in air at 25°C	$v_s = 346$ m s^{-1}

Gravity and motion	
Gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
Mass of the Earth	$m_E = 5.97 \times 10^{24}$ kg

Electromagnetism	
Coulomb's constant	$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$
Magnetic constant	$\mu_0 = 4\pi \times 10^{-7} \; T\,A^{-1} \text{ m}$

Quantum theory	
Wien's displacement constant	$b = 2.898 \times 10^{-3} \text{ m K}$
Planck's constant	$h = 6.626 \times 10^{-34} \text{ J s}$
Rydberg's constant	$R = 1.097 \times 10^7 \text{ m}^{-1}$

SCIENTIFIC NOTATION

Ratio to basic unit	Prefix	Abbreviation
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10	deca	da
10^2	hecto	h
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T

LIST OF ELEMENTS BY NAME

Name	Atomic no.	Symbol	Name	Atomic no.	Symbol
Hydrogen	1	H	Krypton	36	Kr
Helium	2	He	Rubidium	37	Rb
Lithium	3	Li	Strontium	38	Sr
Beryllium	4	Be	Yttrium	39	Y
Boron	5	B	Zirconium	40	Zr
Carbon	6	C	Niobium	41	Nb
Nitrogen	7	N	Molybdenum	42	Mo
Oxygen	8	O	Technetium	43	Tc
Fluorine	9	F	Ruthenium	44	Ru
Neon	10	Ne	Rhodium	45	Rh
Sodium	11	Na	Palladium	46	Pd
Magnesium	12	Mg	Silver	47	Ag
Aluminium	13	Al	Cadmium	48	Cd
Silicon	14	Si	Indium	49	In
Phosphorus	15	P	Tin	50	Sn
Sulfur	16	S	Antimony	51	Sb
Chlorine	17	Cl	Tellerium	52	Te
Argon	18	Ar	Iodine	53	I
Potassium	19	K	Xenon	54	Xe
Calcium	20	Ca	Cesium	55	Cs
Scandium	21	Sc	Barium	56	Ba
Titanium	22	Ti	Lanthanum	57	La
Vanadium	23	V	Cerium	58	Ce
Chromium	24	Cr	Praseodymium	59	Pr
Manganese	25	Mn	Neodymium	60	Nd
Iron	26	Fe	Promethium	61	Pm
Cobalt	27	Co	Samarium	62	Sm
Nickel	28	Ni	Europium	63	Eu
Copper	29	Cu	Gadolinium	64	Gd
Zinc	30	Zn	Terbium	65	Tb
Gallium	31	Ga	Dysprosium	66	Dy
Germanium	32	Ge	Holmium	67	Ho
Arsenic	33	As	Erbium	68	Er
Selenium	34	Se	Thulium	69	Tm
Bromine	35	Br	Ytterbium	70	Yb

LIST OF ELEMENTS BY NAME (continued)

Name	Atomic no.	Symbol	Name	Atomic no.	Symbol
Lutetium	71	Lu	Americium	95	Am
Hafnium	72	Hf	Curium	96	Cm
Tantalum	73	Ta	Berkelium	97	Bk
Tungsten	74	W	Californium	98	Cf
Rhenium	75	Re	Einsteinium	99	Es
Osmium	76	Os	Fermium	100	Fm
Iridium	77	Ir	Mendelevium	101	Md
Platinum	78	Pt	Nobelium	102	No
Gold	79	Au	Lawrencium	103	Lr
Mercury	80	Hg	Rutherfordium	104	Rf
Thallium	81	Tl	Dubnium	105	Db
Lead	82	Pb	Seaborgium	106	Sg
Bismuth	83	Bi	Bohrium	107	Bh
Polonium	84	Po	Hassium	108	Hs
Astatine	85	At	Meitnerium	109	Mt
Radon	86	Rn	Darmstadtium	110	Ds
Francium	87	Fr	Roentgenium	111	Rg
Radium	88	Ra	Copernicum	112	Cn
Actinium	89	Ac	Nihonium	113	Nh
Thorium	90	Th	Flerovium	114	Fl
Protactinium	91	Pa	Moscovium	115	Mc
Uranium	92	U	Livermorium	116	Lv
Neptunium	93	Np	Tennessine	117	Ts
Plutonium	94	Pu	Oganesson	118	Og

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PERIODIC TABLE OF THE ELEMENTS

KEY

1	atomic number
H	symbol
1.01	relative atomic mass*

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																		**2** **He** 4.00
3 **Li** 6.94	**4** **Be** 9.01												**5** **B** 10.81	**6** **C** 12.01	**7** **N** 14.01	**8** **O** 16.00	**9** **F** 19.00	**10** **Ne** 20.18
11 **Na** 22.99	**12** **Mg** 24.31												**13** **Al** 26.98	**14** **Si** 28.09	**15** **P** 30.97	**16** **S** 32.06	**17** **Cl** 35.45	**18** **Ar** 39.95
19 **K** 39.10	**20** **Ca** 40.08		**21** **Sc** 44.96	**22** **Ti** 47.87	**23** **V** 50.94	**24** **Cr** 52.00	**25** **Mn** 54.94	**26** **Fe** 55.85	**27** **Co** 58.93	**28** **Ni** 58.69	**29** **Cu** 63.55	**30** **Zn** 65.38	**31** **Ga** 69.72	**32** **Ge** 72.63	**33** **As** 74.92	**34** **Se** 78.97	**35** **Br** 79.90	**36** **Kr** 83.80
37 **Rb** 85.47	**38** **Sr** 87.62		**39** **Y** 88.91	**40** **Zr** 91.22	**41** **Nb** 92.91	**42** **Mo** 95.95	**43** **Tc** (98.91)	**44** **Ru** 101.07	**45** **Rh** 102.91	**46** **Pd** 106.42	**47** **Ag** 107.87	**48** **Cd** 112.41	**49** **In** 114.82	**50** **Sn** 118.71	**51** **Sb** 121.76	**52** **Te** 127.60	**53** **I** 126.90	**54** **Xe** 131.29
55 **Cs** 132.91	**56** **Ba** 137.33	**57–71** Lathanoids	**72** **Hf** 178.49	**73** **Ta** 180.95	**74** **W** 183.84	**75** **Re** 186.21	**76** **Os** 190.23	**77** **Ir** 192.22	**78** **Pt** 195.08	**79** **Au** 196.97	**80** **Hg** 200.59	**81** **Tl** 204.38	**82** **Pb** 207.2	**83** **Bi** 208.98	**84** **Po** (210.0)	**85** **At** (210.0)	**86** **Rn** (222.0)
87 **Fr** (223.0)	**88** **Ra** (226.1)	**89–103** Actinoids	**104** **Rf** (261.1)	**105** **Db** (262.1)	**106** **Sg** (263.1)	**107** **Bh** (264.1)	**108** **Hs** (265.1)	**109** **Mt** (268)	**110** **Ds** (281)	**111** **Rg** (272)	**112** **Cn** (285)	**113** **Nh** (284)	**114** **Fl** (289)	**115** **Mc** (288)	**116** **Lv** (293)	**117** **Ts** (294)	**118** **Og** (294)

Lathanoids

57 **La** 138.91	**58** **Ce** 140.12	**59** **Pr** 140.91	**60** **Nd** 144.24	**61** **Pm** (146.9)	**62** **Sm** 150.36	**63** **Eu** 151.96	**64** **Gd** 157.25	**65** **Tb** 158.93	**66** **Dy** 162.50	**67** **Ho** 164.93	**68** **Er** 167.26	**69** **Tm** 168.93	**70** **Yb** 173.05	**71** **Lu** 174.97

Actinoids

89 **Ac** (227.0)	**90** **Th** 232.0	**91** **Pa** 231.0	**92** **U** 238.0	**93** **Np** (237.0)	**94** **Pu** (239.1)	**95** **Am** (241.1)	**96** **Cm** (244.1)	**97** **Bk** (249.1)	**98** **Cf** (252.1)	**99** **Es** (252.1)	**100** **Fm** (252.1)	**101** **Md** (258.1)	**102** **No** (259.1)	**103** **Lr** (262.1)

Groups are numbered according to IUPAC convention 1–18.
*Values in brackets are for the isotope with the longest half-life.