Semester Two Examination 2017

Question/Answer Booklet

CORPUS CHRISTI COLLEGE

SEQUERE DOMINUM

PHYSICS

12 ATAR

Student Number: In Figures ☐☐ ☐☐☐ ☐☐☐

In words _____

_____

Time allowed for this paper

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet/Formulae and Data Booklet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, ruler and highlighters

Special items: non-programmable calculators approved for use in this examination, drawing templates, drawing compass and a protractor

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

End of questions

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short answers	11	11	50	53	30
Section Two: Problem-solving	7	7	90	91	50
Section Three: Comprehension	2	2	40	36	20
				Total	100

Instructions to candidates

1. The rules for the conduct of the Western Australian Certificate of Education ATAR course examinations are detailed in the *Year 12 Information Handbook 2017*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet.

3. When calculating or estimating answers, show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning.

   In calculations, give final answers to three significant figures and include appropriate units where applicable.

   In estimates, give final answers to a maximum of two significant figures and include appropriate units where applicable.

4. You must be careful to con ne your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

6. The Formulae and Data booklet is not to be handed in with your Question/Answer booklet.

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Additional Data

Table of common mesons

Particle	Structure	Charge	Baryon Number	Strangeness
π^0	$u\bar{u}$ or $d\bar{d}$	0	0	0
π^+	$u\bar{d}$	+1	0	0
π^-	$\bar{u}d$	-1	0	0
K^0	$d\bar{s}$	0	0	+1
K+	$u\bar{s}$	+1	0	+1
K^-	$\bar{u}s$	-1	0	-1

Properties of quarks
antiquarks have opposite signs

type	*charge*	*baryon number*	*strangeness*
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of leptons

	lepton number
particles: e^-, ν_e ; μ^-, ν_μ	+1
antiparticles: e^+, $\overline{\nu_e}$; μ^+, $\overline{\nu_\mu}$	–1

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Redshift and recessional velocity

$$z = \frac{\Delta\lambda}{\lambda}$$

It can also be shown that:

$$z = \frac{v}{c_0}$$

Where:
- z = redshift
- $\Delta\lambda$ = change in wavelength (moving source) (nm)
- λ = wavelength of stationary source (nm)
- v = recessional speed of galaxy (ms^{-1})
- c_0 = speed of light in a vacuum (ms^{-1})

Hubble's Law

$$v_{galaxy} = H_0 . d$$

- V_{galaxy} = recessional speed of galaxy (ms^{-1})
- d = distance to galaxy (Mpc)
- H_o = Hubble's constant ($Kms^{-1}Mpc^{-1}$)

See next page

Section One. Short response. **30% (53 Marks)**

This section has **11** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 50 minutes.

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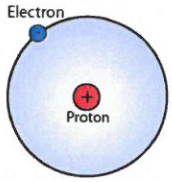
1. The distance between the proton and the electron in the ground state of the hydrogen atom is defined as the Bohr radius. Given that the Bohr radius can be measured as $r = 5.29 \times 10^{-11}$ metres, calculate the speed with which the electron circles the nucleus. **[5 marks]**



$$F_c = F_q \checkmark$$

$$\frac{mv^2}{r} = \frac{Kq_1q_2}{r^2} \checkmark$$

$$\therefore v^2 = \frac{Kq_1q_2}{mr} = \frac{(9\times10^9)(1.6\times10^{-19})^2}{(9.11\times10^{-31})(5.29\times10^{-11})} \checkmark$$

$$v^2 = 4.77\times10^{12} \checkmark$$

$$\therefore \underline{v = 2.18\times10^6\ ms^{-1}.} \checkmark$$

5

2. Consider the decay equation shown here showing the hadronic process of lambda decay.

$$\Lambda \rightarrow p + \pi^-$$

Note: Λ = uds, p = uud, π^- = d$\underline{u}$

a) Show that charge and baryon number are conserved. **[2 marks]**

Charge $\left(\frac{2}{3}\right)\left(-\frac{1}{3}\right)\left(-\frac{1}{3}\right) \rightarrow \left(\frac{2}{3}\right)\left(\frac{2}{3}\right)\left(-\frac{1}{3}\right) + \left(-\frac{1}{3}\right)\left(-\frac{2}{3}\right)$ ✓

Baryon number $1 \rightarrow 1 + 0$ ✓

(2)

b) Is strangeness conserved? All working must be shown to explain your answer. **[3 marks]**

$-1 \rightarrow 0 + 0$ ✓

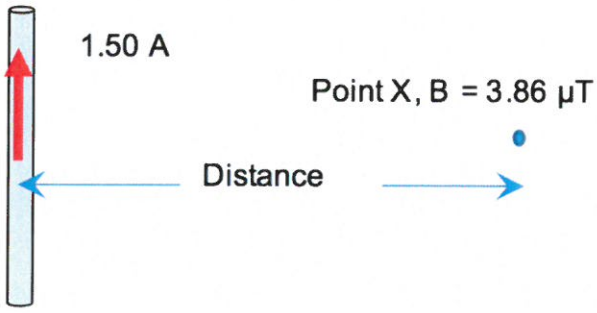
STRANGNESS IS NOT CONSERVED ✓ BUT

THIS IS OKAY SINCE STRANGENESS ✓

ISN'T ALWAY CONSERVED FOR WEAK FORCE.

(3)

3. A wire is conducting a DC current of 1.50 A. At point X a magnetic flux density of 3.86×10^{-6} T is detected. Calculate the distance between the current carrying wire and point X. You can ignore the effects of the Earth's magnetic field in this question. **[2 marks]**



$$B = \frac{\mu_0 I}{2\pi r}$$

$$\therefore \quad r = \frac{\mu_0 I}{2\pi B} = \frac{(4\pi \times 10^{-7})(1.5)}{2\pi r}$$ ✓

(2)

$$\therefore \quad r = 7.77 \times 10^{-2}\ \text{m}.$$ ✓

(7)

4. A proton has been accelerated to 95% of the speed of light in the Large Hadron Collider (LHC). Calculate its energy. **[3 marks]**

$$E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$

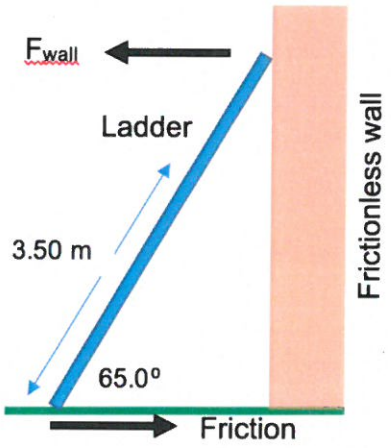
$$= \frac{(1.67 \times 10^{-27})(9 \times 10^{16})}{\sqrt{1 - \frac{0.95^2}{1}}}$$

$$E = 4.81 \times 10^{-10}\ \text{J}.$$

(3)

5. The diagram shows a uniform ladder of mass 20 kg and length 5.00 m resting on firm ground and against a frictionless wall. Friction acts at the base of the ladder from the ground as shown to stop the ladder collapsing. The force from the wall ($\mathbf{F_{wall}}$) and friction both act in the horizontal and are in equilibrium. A person of mass 80.0kg is standing on the ladder 3.50 m from the base. A normal reaction force at the base of the ladder and the two weight forces act in the vertical direction on the ladder.

The ladder makes an angle of 65.0° with the ground



a) Calculate the force of friction acting on the ladder in the position shown. **[4 marks]**

$$\Sigma_{ACW} = \Sigma_{CW}$$

(4)

$$(5)\,F(\sin 65^\circ) = (3.5)(80)(9.8)(\sin 25^\circ) + (2.5)(20)(9.8)(\sin 25^\circ)$$

$$F = 302\ \text{N}.$$

(7)

b) If the angle that the ladder makes to the horizontal is changed to 45° how would this change the magnitude of friction required to maintain equilibrium. The friction would:

Increase	Stay the same	Decrease	Insufficient data to determine

Circle a response and explain your choice: **[3 marks]**

- ΣCW INCREASES DUE TO CHG IN θ FROM 25° TO 45°.
- ΣACW MUST INCREASE TO MAINTAIN EQUILIBRIUM $\therefore$ f MUST INCREASE.

(3)

6. A subatomic particle consisting of a quark-antiquark pair, has a rest-life measured to be 2.34×10^{-8} seconds in the laboratory. What is the speed of the same particle, if its average lifetime is measured to be 3.95×10^{-8} seconds, in a cosmic ray experiment? **[6 marks]**

$$t = \frac{t_0}{\sqrt{1 - v^2/c^2}} \qquad t = 2.34 \times 10^{-8}\ s. \qquad t_0 = 3.95 \times 10^{-8}\ s.$$

(6)

$$(3.95 \times 10^{-8}) = \frac{(2.34 \times 10^{-8})}{\sqrt{1 - v^2/c^2}}$$

$$(3.95 \times 10^{-8})\sqrt{1 - v^2/c^2} = (2.34 \times 10^{-8}).$$

$$(1.56 \times 10^{-15})\left(1 - \frac{v^2}{c^2}\right) = 5.48 \times 10^{-16}.$$

$$\therefore -(1.73 \times 10^{-32})v^2 = (5.48 \times 10^{-16}) - (1.56 \times 10^{-15})$$

$$v^2 = \frac{1.012 \times 10^{-15}}{1.73 \times 10^{-32}} \qquad \therefore v = 2.42 \times 10^{8}\ ms^{-1}.$$

(9)

See next page

7. The light received from many distant galaxies is red-shifted.

a) State the cause of this red-shift, use a diagram to explain your answer. **[3 marks]**

- EXPANSION OF SPACE-TIME ✓
- WAVELENGTHS ARE STRETCHED. ✓
-  ✓

3

b) A spectral line of light from a laboratory source has a wavelength of 658 nm. The wavelength of this line of light from a distant galaxy (NGC5128) is 670 nm. Calculate the recessional speed of NGC5128. **[2 marks]**

$$V = \frac{\Delta\lambda}{\lambda} c = \frac{670 - 658}{658} (3 \times 10^8) \quad \checkmark$$

$$\therefore V = 0.018\, c$$

$$= \underline{5.47 \times 10^3 \text{ kms}^{-1}}. \quad \checkmark$$

2

c) Given that a current value for Hubble's constant is $72 \text{kms}^{-1}\text{Mpc}^{-1}$, how far is the observer from NGC5128? **[2 marks]**

$$V = H_0 d$$

$$\therefore d = \frac{V}{H_0} = \frac{5.47 \times 10^3}{72} \quad \checkmark$$

$$= \underline{74.9 \text{ Mpc}}. \quad \checkmark$$

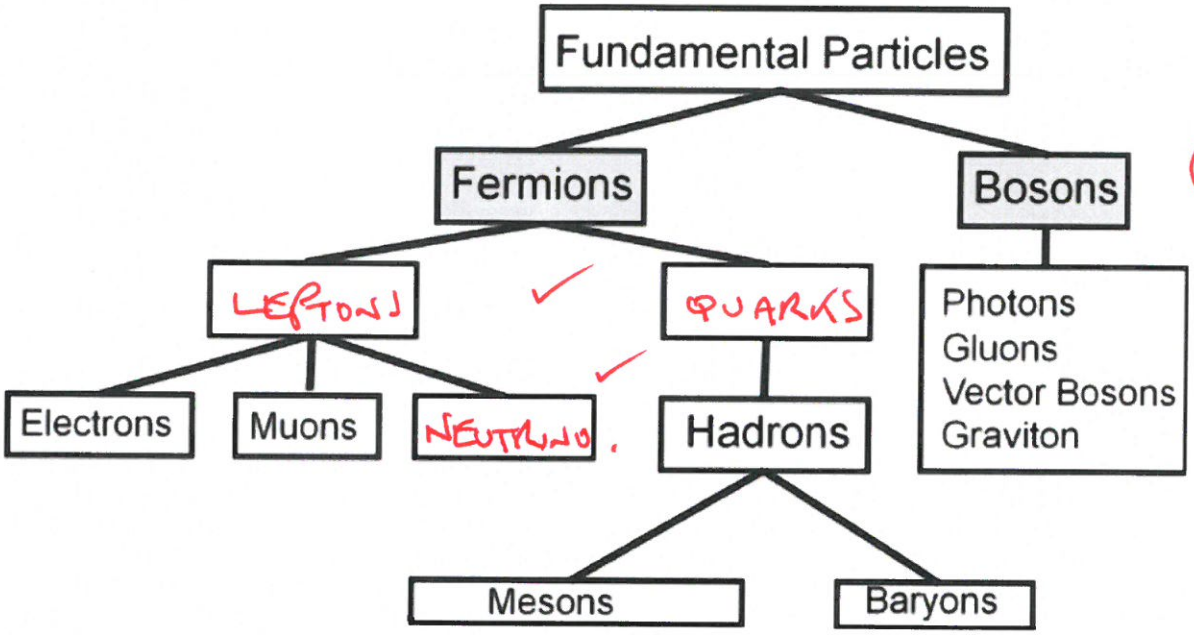
2

See next page

7

8. Consider the table of elementary particles shown below.

a) Write the missing headings in the spaces provided. **[2 marks]**



2

b) Briefly explain the difference between mesons and baryons. **[2 marks]**

- MESON = $q\bar{q}$ PAIR. ✓
- BARYON = qqq (or) $\bar{q}\bar{q}\bar{q}$ ✓

2

9. Explain what is meant by the term, ***"Ultraviolet catastrophe"***. **[3 marks]**

- CLASSICAL PHYSICS STATES THAT A BLACK BODY AT THERMAL EQUILIBRIUM WILL EMITT RADIATION AT ALL FREQ'S, EMITTING MORE ENERGY AS THE FREQ INCREASES. THIS BREAKS DOWN WHEN FREQ'S REACH UV OR GREATER.

3

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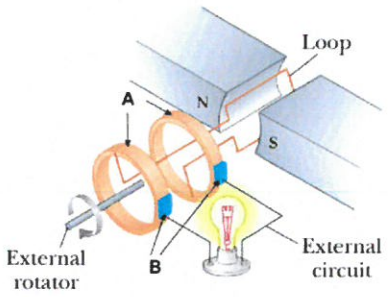
7

10. An AC Generator has an armature with an area of 4.7×10^{-2} m^2. The coil rotates from vertical to horizontal in 25ms, through a magnetic field strength of 0.43T.



a) Identify the parts 'A' and 'B' shown in the diagram. **[1 mark]**

Part 'A' SLIP RINGS ½ Part 'B' BRUSHES. ½ 1

b) How many loops must the coil contain in order to generate a potential difference (V_{max}) of 175 volts? **[3 marks]**

$T = (4)(0.025)$

$= 0.1\text{s}$

$\therefore f = 10\text{Hz}$ ✓

3

$EMF = -2\pi NBAf$

$\therefore N = \dfrac{EMF}{2\pi BAf}$ ✓

$N = \dfrac{175}{(6.28)(0.43)(4.7\times10^{-2})(10)}$

$= \underline{\underline{138 \text{ LOOPS.}}}$ ✓

4

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11. A photoelectric effect experiment was performed in which a monochromatic light beam was shone onto a clean metal surface. The wavelength of the incident beam was varied and the maximum kinetic energy of the emitted photoelectrons was recorded in the table below.

Wavelength (nm)	Frequency (Hz)	KE_{max} (eV)	KE_{max} (J)
750	4.00×10^{14}	0.22	3.52×10^{-20}
587	5.11×10^{14} ✓	0.67	1.07×10^{-19} ✓
506	5.93×10^{14}	0.98	1.57×10^{-19}
444	6.76×10^{14}	1.35	2.16×10^{-19}.
400	7.50×10^{14}	1.63	2.61×10^{-19}

a) Briefly explain the significance of the photoelectric effect to modern physics. **[2 marks]**

THE PHOTOELECTRIC EFFECT DEMONSTRATES THE QUANTISATION OF ENERGY AND THE PARTICLE NATURE OF LIGHT. (2)

b) Complete the table for the missing values. **[2 marks]** (2)

c) By making use of the data from the table, calculate the work function of the clean metal surface used during this experiment. **[3 marks]**

$E_{ph} = hf = E_K + \phi$ (3)

$\therefore \phi = hf - E_K$ ✓

$= (6.63 \times 10^{-34})(4 \times 10^{14}) - (3.52 \times 10^{-20})$ ✓

$= \underline{1.44 \text{ eV}}$. ✓

(7)

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