MARKER CODE		Student Personal Identification Number

South Pacific Form Seven Certificate

PHYSICS

2015

QUESTION and ANSWER BOOKLET

Time allowed: Two and a half hours

INSTRUCTIONS

Write your **Student Personal Identification Number (SPIN)** in the space provided on the top right hand corner of this page.

Answer **ALL QUESTIONS**. Write your answers in the spaces provided in this booklet. If you need more space for answers, ask the Supervisor for extra paper. Write your SPIN on all extra sheets used and clearly number the questions. Attach the extra sheets at the appropriate places in this booklet.

Major Learning Outcomes (Achievement Standards)	Skill Level			Weight /Time
	Basic	Proficient	Advanced	
PhyB: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in waves	**7 questions**	**2 questions**	**1 question**	**14%** 30 min
PhyA: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in mechanics	**12 questions**	**3 questions**	**2 questions**	**24%** 53 min
PhyC: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in electricity and electromagnetism	**9 questions**	**3 questions**	**2 questions**	**21%** 45 min
PhyD: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in atomic and nuclear physics	**6 questions**	**1 questions**	**1 question**	**11%** 22 min
TOTAL	**34 Learning outcomes**	**9 Learning outcomes**	**6 Learning outcomes**	**150 min**

Check that this booklet contains pages 2-16 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION

SECTION A: WAVES

(30 minutes)

Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in waves

A1 **SOUND**

The speed of sound in air is 3.40×10^2 m s^{-1}

One day in her physics class, Emma pulls her pen to bits. This creates a narrow hollow pipe, open at the top end and closed at the bottom. It was 0.130 m long. She blows across the top end of the pipe and makes a note of a certain frequency.

Assessor's use only

A1a Draw the fundamental standing wave on the diagram below. Identify all displacement nodes (N) and antinodes (A).

Basic	Level
Excellent	
Weak	
NR	

A1b Show that the wavelength of the fundamental standing wave produced is 0.520 m.

Basic	Level
Excellent	
Weak	
NR	

A1c Calculate the frequency of the fundamental standing wave produced.

Basic	Level
Excellent	
Weak	
NR	

A1 **SOUND**

The speed of sound in air is 3.40×10^2 m s^{-1}

Ben, who is also in the same class, makes a similar pipe but with a different length. Ben's pipe produced a fundamental standing wave frequency of 1.10×10^3 Hz. While blowing his pipe, Ben runs towards Emma who is standing on the other side of the room. Emma hears a frequency of 1.11×10^3 Hz.

Assessor's use only

A1d Explain, using physical principles, why Emma hears an increased frequency.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

A1e Show that Ben's velocity is 3.06 m s^{-1}.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

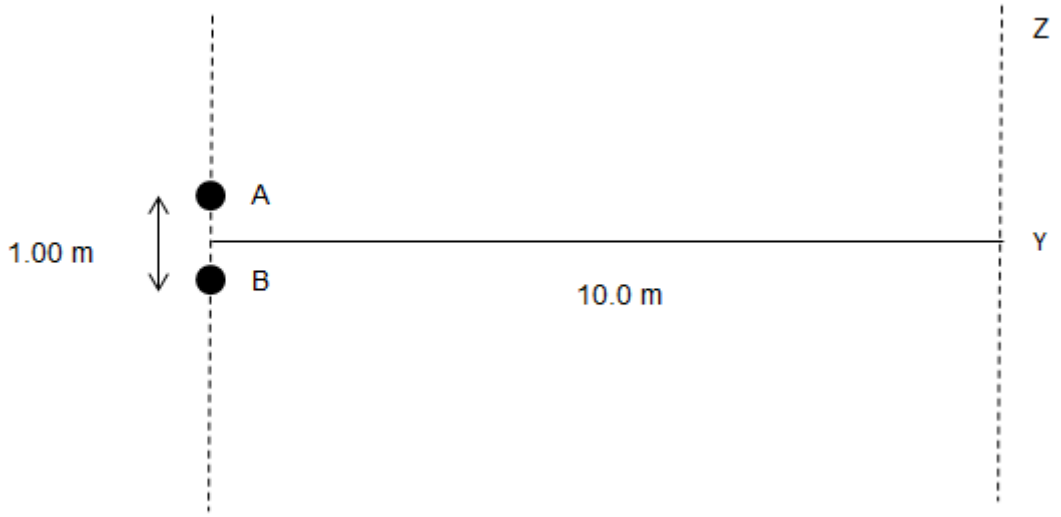
A1f Show that the length of Ben's pipe is 7.73×10^{-2} m.

Basic	Level
Excellent	
Weak	
NR	

A1g Ben blows across the top of his pipe with more force. By doing this he produces the first overtone. Show that the frequency of the first overtone is 3.30×10^3 Hz.

Basic	Level
Excellent	
Weak	
NR	

Two identical speakers are positioned at points A and B as shown on the diagram below. The speakers are 1.00 m apart. The pipes are played so that they both produce frequencies of 2.00×10^3 Hz and are in phase with each other.



Assessor's use only

A1h State the physical process that produces the maxima and minima heard as someone walks from Y to Z.

_____

Basic	Level
Excellent	
Weak	
NR	

A1i Show that the distance from Y to the first maximum produced is approximately 1.7 m.

_____

_____

_____

_____

Basic	Level
Excellent	
Weak	
NR	

A1j The above experiment was performed at a large empty field. Discuss why the experiment could produce different results if performed in a large closed room.

_____

_____

_____

_____

_____

_____

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

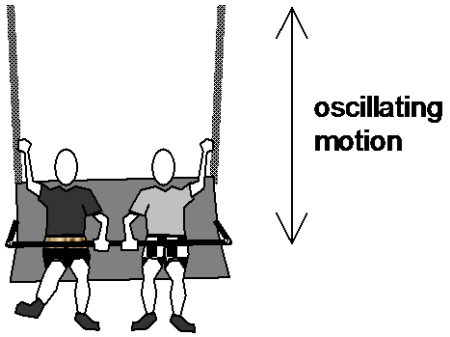
SECTION B: MECHANICS

(53 minutes)

Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in mechanics

B1 **Vertical Bungy**

As part of an amusement ride, a carriage and riders are pulled vertically down, stretching some bungy cords, and are then released. They accelerate vertically upward until gravity takes over and brings them back down. After a few seconds the carriage is oscillating vertically with simple harmonic motion. The spring constant is 4.99×10^3 N m^{-1}. The combined mass of the system of carriage and riders is 531 kg.



Assessor's use only

B1a Show that the period of the motion is 2.05 s.

Basic	Level
Excellent	
Weak	
NR	

B1b At the start of the simple harmonic motion, the carriage oscillates with an amplitude of 4.20 m.

Show that the angular frequency of the oscillations is 3.07 rad s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

B1c Show that the maximum speed is 12.9 m s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

B1d Where in the motion did this maximum speed occur?

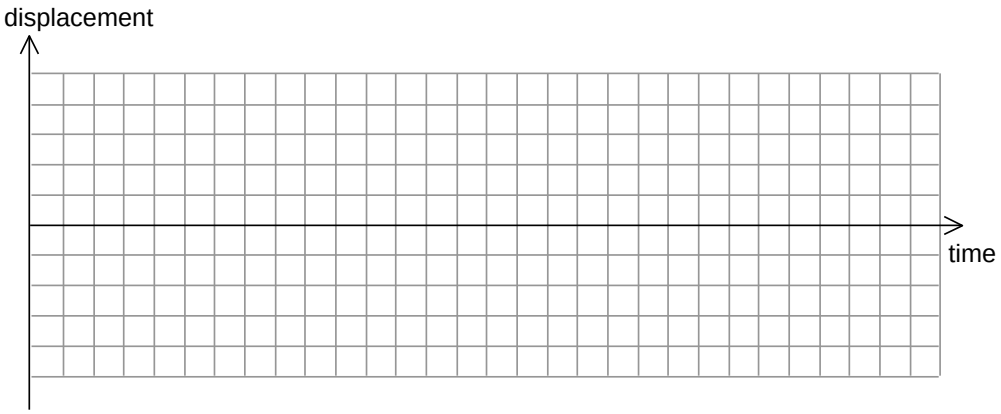
Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

B1e Calculate the kinetic energy of the mass when it has maximum speed.

Basic	Level
Excellent	
Weak	
NR	

B1f The amplitude of the oscillations of the carriage quickly reduces.
It takes 3 complete oscillations from when the carriage passes through the equilibrium position until it has stopped moving. On the grid below, sketch a graph of displacement against time for the 3 oscillations.



Proficient	Level
Excellent	
Moderate	
Weak	
NR	

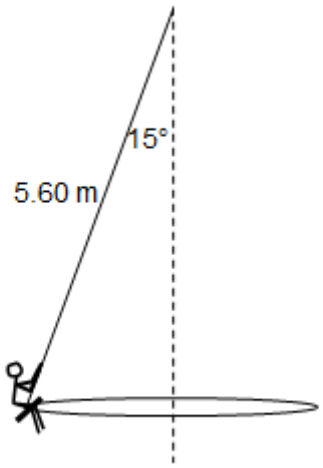
B1g The bungy cord system consists of two identical bungy cords.
Explain why the spring constant of the system of cords is twice the spring constant of a single cord.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

B2 **THE CIRCULAR SWING**

The acceleration due to gravity = 9.80 m s^{-2}

At a camp, Paul and John use a rope swing that is 5.60 m long. Paul pushes John, whose mass is 65.0 kg, so that he moves around in a horizontal circle. His circular motion makes the rope have an angle of 15.0 degrees from the vertical.



Assessor's use only

B2a State the names of the two forces acting on John.

Basic	Level
Excellent	
Weak	
NR	

B2b State why the vertical forces acting on John are balanced.

Basic	Level
Excellent	
Weak	
NR	

B2c The horizontal force on John is unbalanced. Describe why.

Basic	Level
Excellent	
Weak	
NR	

B2d Calculate the weight force acting on John.

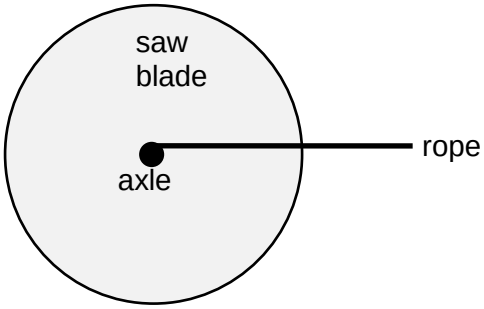
Basic	Level
Excellent	
Weak	
NR	

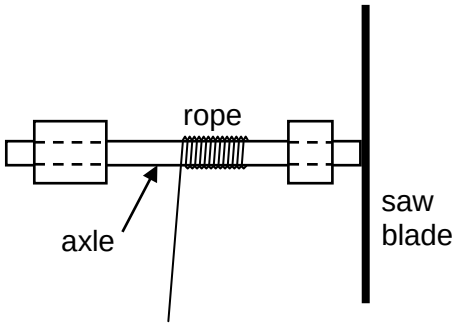
Assessor's use only

B2e	Show that the tension in the rope, while John is swinging in a circle, is 659 N.	**Proficient** / **Level** Excellent Moderate Weak NR
B2f	Show that the centripetal force acting is 171 N.	**Basic** / **Level** Excellent Weak NR
B2g	Calculate John's speed as he rides in circles on the swing.	**Proficient** / **Level** Excellent Moderate Weak NR

B2

One of the activities at the camp is to cut firewood for the camp wood burner. Paul and John find an old broken down circular wood saw. They disconnect the motor and wrap a 6.00 m long rope around the axle.





The axle has a radius of 0.051 m.

Paul pulls the rope to make the axle and saw blade turn.

Assessor's use only

B2h

He pulls with a force of 250 N. Assuming negligible friction losses in the system, show that the rotational kinetic energy of the saw and axle when the end of rope comes off the axle is 1500 J.

Basic	Level
Excellent	
Weak	
NR	

B2i

Paul accelerates uniformly while pulling the rope and reaches a speed of 2.30 m s^{-1} when the rope comes off the axle. Show that this will cause the saw to have a final angular speed of 45.1 rad s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

B2j

In a working saw, the large circular saw blade acts as a flywheel to store rotational kinetic energy. Explain why the saw blade is more effective at storing rotational kinetic energy than the axle, despite the fact that they are connected to each other and are rotating at the same angular speed. Explain any assumptions you have to make.

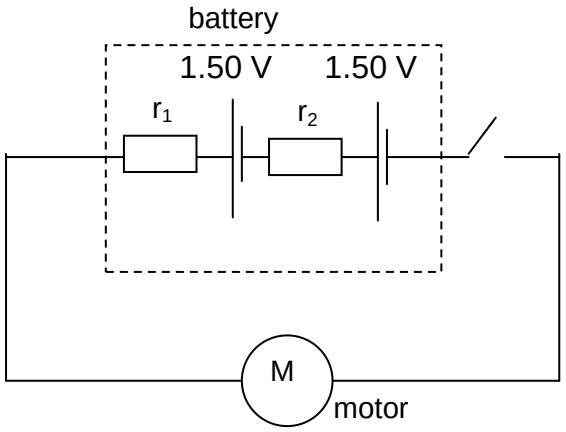
Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

SECTION C: ELECTRICITY AND ELECTROMAGNETISM (45 minutes)

Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in electricity and electromagnetism

C1 **THE ELECTRIC TOOTHBRUSH**

Ben has a battery-operated electric toothbrush. The toothbrush contains two cells, each with an emf of 1.50 V. The electrical circuit of the toothbrush is shown below. The cells have internal resistance r_1 and r_2.



Assessor's use only

C1a Describe why the total voltage of the circuit is 3.00 V.

Basic	Level
Excellent	
Weak	
NR	

C1b Calculate the amount of energy given to one coulomb of charge that passes across a voltage of 3.00 V.

Basic	Level
Excellent	
Weak	
NR	

C1c When fully charged, the power output of the electric motor is 5.00 W and the voltage across it is 2.80 V.

Show that the current through the electric motor is 1.79 A.

Basic	Level
Excellent	
Weak	
NR	

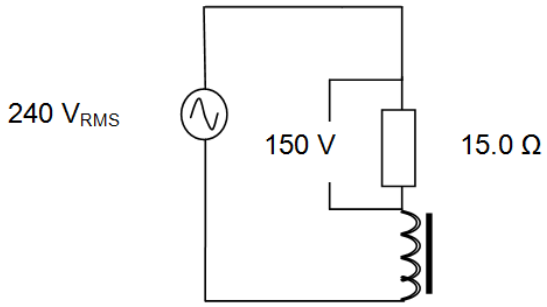
Assessor's use only

C1d	Explain why the voltage across the battery reduces when the switch is closed. _____ _____ _____ _____ _____ _____	**Proficient** / **Level** Excellent Moderate Weak NR
C1e	Show that the total internal resistance of the fully charged cells is 0.112 ohms. _____ _____ _____ _____	**Advanced** / **Level** Excellent Moderate Low Weak NR Exceed

C2 **MOTORS AND AC**

Worldwide, a large amount of electrical energy is used to drive electric motors. An electric motor contains a large coil of wire and hence acts as an inductor. The coil of wire also has resistance. The motor can be thought of as an inductor in series with a resistor.

One particular motor is connected to a 240 V_{RMS} AC supply as shown in the diagram below.

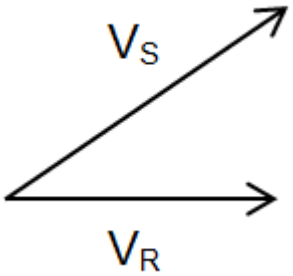


Assessor's use only

C2a Show that the rms current in the resistor is 10.0 A.

Basic	Level
Excellent	
Weak	
NR	

C2b The following phasor diagram (not drawn to scale) shows the supply voltage and the voltage across the resistor. Draw the phasor for the inductor voltage.



Basic	Level
Excellent	
Weak	
NR	

C2c Show that the value of the voltage across the inductor is 187 V_{RMS}.

Basic	Level
Excellent	
Weak	
NR	

C2d Show that the value of the reactance of the inductor is 18.7 ohms.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

C2e	Calculate the impedance of the circuit.	**Basic** / **Level** Excellent Weak NR
C2f	The inductance of the motor is 0.165 H. Calculate the frequency of the AC supply.	**Proficient** / **Level** Excellent Moderate Weak NR
C2g	If the frequency of the variable AC supply is increased, describe what will happen to the reactance of the inductor.	**Basic** / **Level** Excellent Weak NR
C2h	If the frequency of the variable AC supply is increased, explain what will happen to the voltage across the resistor.	**Proficient** / **Level** Excellent Moderate Weak NR
C2i	Explain what you could add to the above circuit to make the current and voltage of the supply run in phase.	**Advanced** / **Level** Excellent Moderate Low Weak NR Exceed

SECTION D: ATOMIC AND NUCLEAR PHYSICS (22 minutes)

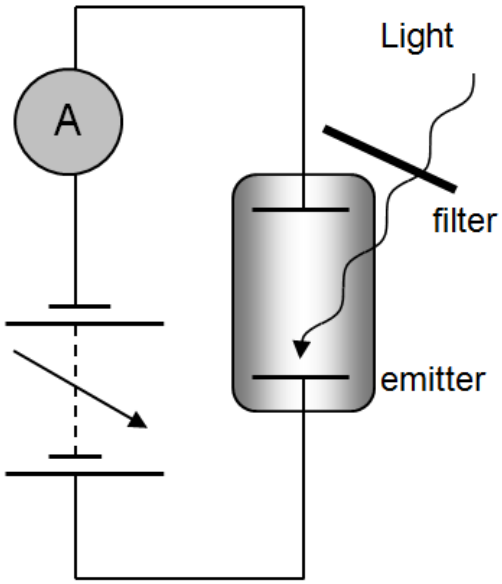
Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in atomic and nuclear physics

D1 **THE LIGHT METER**

Planck's constant = 6.63×10^{-34} J s

A student is going to use a camera as part of a project on light. As part of the project the student investigates a light meter that utilizes a photoelectric cell.

Light shining on the emitter causes electrons to be emitted and produces a current. The circuit diagram of a cell is shown below.



Assessor's use only

D1a Einstein derived the following relationship to describe the photoelectric effect:
$hf = \phi + E_K$
State the meaning of the following symbols:

h _____

f _____

ϕ _____

Basic	Level
Excellent	
Weak	
NR	

D1b The student shines light of frequency 6.16×10^{14} Hz on the photoelectric cell. Calculate the energy of the light photons.

_____

_____

_____

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

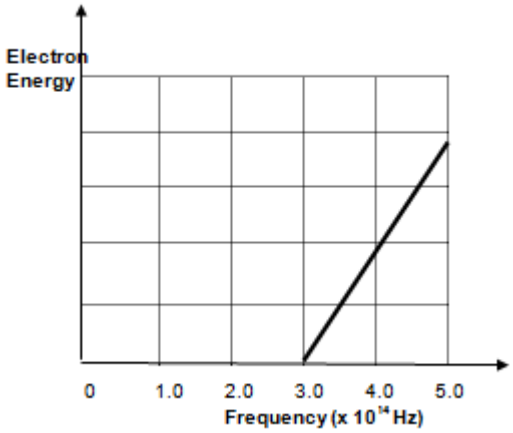
D1c The frequency is kept constant but the light is made much brighter. Describe what effect this has on the size of the current.

Basic	Level
Excellent	
Weak	
NR	

D1d A photon of sufficient energy to release an electron is incident on the emitter. State whether or not there is a time delay before the release of the electron.

Basic	Level
Excellent	
Weak	
NR	

D1e By adjusting the voltage of the battery the kinetic energy of the electrons can be found. The graph below shows the relationship between the kinetic energy of the released electrons and the frequency of light incident on the cell.



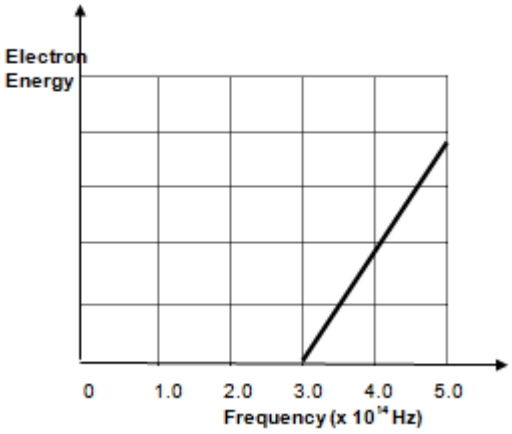
State what would happen to the current if light of frequency 2.0 x 10^{14} Hz was incident on the photoelectric cell.

Basic	Level
Excellent	
Weak	
NR	

D1f Explain how the battery can be used to find the kinetic energy of the emitted electrons.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

Assessor's use only

D1g	Each photon of frequency 6.16×10^{14} Hz will release an electron with a maximum kinetic energy of 5.60×10^{-20} J. Calculate the work function of the metal. _____ _____	**Basic** / **Level** Excellent Weak NR
D1h	If the metal of the photoelectric cell is now changed to one with a lesser work function, draw a line on the graph below to represent how the electron's kinetic energy would depend on the frequency of the incident light.  	**Proficient** / **Level** Excellent Moderate Weak NR