MARKER CODE

Student Personal Identification Number

South Pacific Form Seven Certificate

PHYSICS

2014

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
	Band 1 *Basic*	Band 2 *Proficient*	Band 3 *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% 30min
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% 53min
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% 45min
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 question	1 question	11% 22min
TOTAL	**34 questions**	**9 questions**	**6 questions**	**70% 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)

A1 **THE TWO LASERS**

The speed of light is 3.00×10^8 m s^{-1}

Ben and Emma are comparing two different coloured lasers. The two lasers emit red and violet light respectively.

Ben shines the red laser through two narrow slits towards a screen. The bright fringes in the pattern seen on the screen are 1.40×10^{-2} m apart. The distance between the two slits is 1.44×10^{-4} m. The distance from the slits to the screen is 3.09 metres.

Assessor's use only

A1a Show that the wavelength of the red laser light is 6.52×10^{-7} m.

Basic	Level
Excellent	
Weak	
NR	

A1b Ben then replaces the red laser with the violet laser. Violet light has a shorter wavelength than red light. Describe what change Ben would see in the separation of the bright fringes on the screen.

Basic	Level
Excellent	
Weak	
NR	

A1c Explain why the pattern of fringes on the screen has changed.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

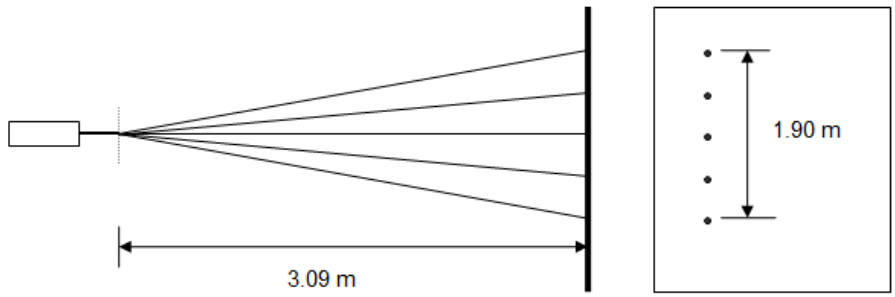
A1d

Ben calculates that the wavelength of the red laser light differs from the wavelength of the violet laser light by a factor of 1.6. Show that the frequency of the violet laser light is 7.36×10^{14} Hz.

Basic	Level
Excellent	
Weak	
NR	

A1e

Emma replaces the two narrow slits with a diffraction grating. Using the **red** laser she measures the distance between five bright fringes and finds it to be 1.90 metres as in the diagram below. The distance to the wall remains constant.



Show that the slit separation on the diffraction grating is 4.44×10^{-6} m.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

A2 **THE PIPES**

Speed of sound in air = 3.40×10^2 m s^{-1}

Emma was playing in her garage and found a set of wooden pipes. The pipes are open at both ends.

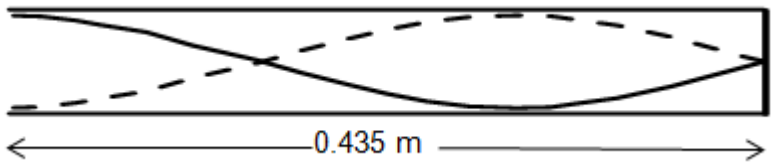
A2a Draw the fundamental standing wave on the diagram below. Identify all displacement nodes (N) and antinodes (A).

Basic	Level
Excellent	
Weak	
NR	

A2b Emma finds that the length of one of the pipes is 0.435 m. Calculate the wavelength of the fundamental standing wave formed in this pipe.

Basic	Level
Excellent	
Weak	
NR	

A2c Emma puts her hand over one end of the pipe to make it a pipe closed at one end. She then blows on to the pipe (closed at one end) and produces the third harmonic (first overtone) as shown below.



Show that the frequency of this harmonic is 586 Hz.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

A2d	Emma later found two tuning forks marked 522 Hz and 510 Hz. She sounds them both at the same time. Calculate the beat frequency heard when the tuning forks are sounded together. _____ _____ _____ _____	**Basic** / **Level** Excellent Weak NR
A2e	Explain, in terms of interference between waves, how beats are produced. _____ _____ _____ _____ _____	**Advanced** / **Level** Excellent Moderate Low Weak NR Exceed

SECTION B: MECHANICS

(53 minutes)

Assessor's use only

B1 **GEOEYE-1**

Universal Gravitational Constant = 6.67×10^{-11} N kg^{-2} m^2
Mass of Earth = 5.98×10^{24} kg

The Earth-imaging satellite GeoEye-1 has a mass of 1260 kg and is positioned 7.06×10^6 m above the Earth's centre of mass.

B1a State the name of the force that keeps the satellite in orbit.

Basic	Level
Excellent	
Weak	
NR	

B1b Show, using Newton's Law of Gravitation, that the gravitational force acting on the satellite is 1.01×10^4 N.

Basic	Level
Excellent	
Weak	
NR	

B1c By equating the answer to b) above to the centripetal force, show that the linear speed of the satellite is 7.52×10^3 m s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

B1d By using Newton's Second Law and the Newton's Law of Gravitation, show that the acceleration due to gravity that the satellite will experience at this position is 8.00 m s^{-2}.

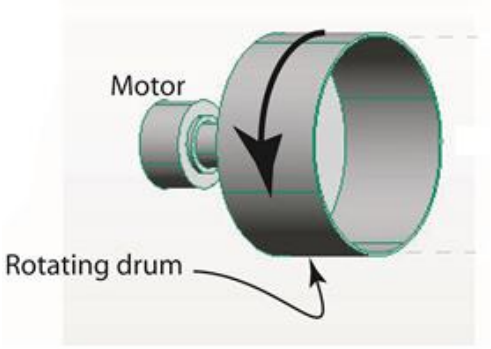
Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

B1e	Explain what will happen to the linear speed of the satellite if it moves to a lower radius orbit. _____ _____ _____ _____ _____ _____	**Advanced** / **Level** Excellent Moderate Low Weak NR Exceed

B2 **THE POLISHING MACHINE**

A device used to polish gemstones contains a horizontally mounted cylindrical barrel. The barrel is driven by a motor. When the motor is on, it produces a constant torque which results in the barrel accelerating uniformly.



The barrel accelerates uniformly from rest to a speed of 1.29×10^2 revolutions per minute in 12.0 seconds.

Assessor's use only

B2a Show that 1.29×10^2 revolutions per minute is equivalent to 13.5 rad s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

B2b Show that the angular acceleration of the barrel during the first 12.0 seconds is 1.13 rad s^{-2}.

Basic	Level
Excellent	
Weak	
NR	

B2c Describe why the answer to (b) is given to three significant figures.

Basic	Level
Excellent	
Weak	
NR	

B2d The rotational inertia of the barrel about its central axis is 0.119 kg m^2.
State the two physical quantities that determine the rotational inertia of an object.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

B2e Calculate the torque supplied by the motor when the barrel is accelerating.

Basic	Level
Excellent	
Weak	
NR	

B2f When spinning at 13.5 rad s^{-1}, the motor is switched off and the barrel continues spinning without friction.

Some gemstones are placed into the spinning barrel. A few seconds later the barrel and the gemstones are spinning together with an angular velocity of 9.50 rad s^{-1}.

State why conservation of angular momentum can be used in this situation.

Basic	Level
Excellent	
Weak	
NR	

B2g Using conservation of angular momentum, show that the rotational inertia of the spinning gemstones is 0.0502 kg m^2.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

B2h The spinning barrel loses kinetic energy after it comes in contact with the gemstones.

Describe what happens to the kinetic energy lost by the barrel.

Basic	Level
Excellent	
Weak	
NR	

B2i The gemstone polishing machine is rather noisy. To reduce noise it is placed inside a wooden box. This results in the top horizontal surface of the box moving up and down in simple harmonic motion. The simple harmonic motion has an amplitude of 2.15 x 10^{-3} m and an angular frequency of 13.5 rad s^{-1}. Show that the maximum velocity of the motion is 0.0290 m s^{-1}.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

B2j

Show that the maximum acceleration of the top horizontal surface of the box is 0.392 m s^{-2}.

Basic	Level
Excellent	
Weak	
NR	

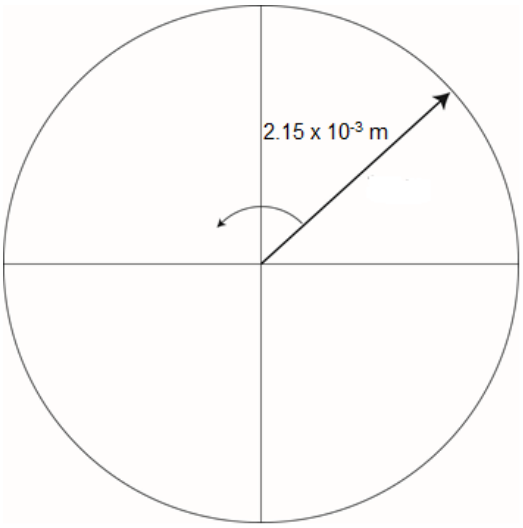
B2k

Explain why an object placed on the top surface of the box will remain connected to the surface.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

B2l

By using the reference circle provided below or any other suitable method, show that the percentage of the time that the top surface of the box is more than 2.0 mm above its equilibrium position is 12.0%.



Not to scale

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

SECTION C: ELECTRICITY AND ELECTROMAGNETISM

(45 minutes)

C1 **CAPACITORS**

Emma's dad is a physics teacher and she finds three capacitors in her dad's workshop.
The capacitors have the following values: 20.0 μF, 40.0 μF and 100 μF (1 μF = 1 x 10^{-6} F).

Assessor's use only

C1a Calculate the maximum value of capacitance that can be made from these three capacitors.

Basic	Level
Excellent	
Weak	
NR	

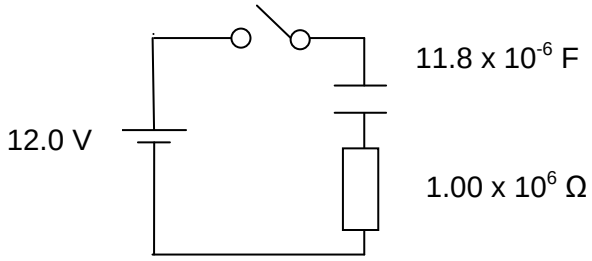
C1b Show that the minimum value of capacitance that can be made from these three capacitors is 11.8 μF.

Basic	Level
Excellent	
Weak	
NR	

C1c Draw the arrangement which produces a capacitance of 11.8 μF.

Basic	Level
Excellent	
Weak	
NR	

C1 Emma connects the 11.8×10^{-6} F capacitor to a 12.0 V battery and a 1.00×10^{6} Ω resistor.



Emma closes the switch and measures the voltage across the capacitor.

Assessor's use only

C1d Sketch a graph showing the voltage across the capacitor after the switch is closed. Label any asymptotes or intercepts.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

C1e Calculate the time constant for this circuit.

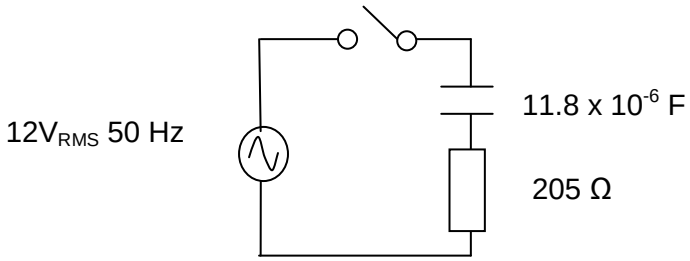
Basic	Level
Excellent	
Weak	
NR	

C1f Describe why the time constant increases when the resistance of the circuit increases.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

C2 **AC CIRCUITS**

Emma connects the 11.8 x 10^{-6} F to a $12V_{RMS}$ 50 HZ AC power supply as in the diagram below.



Assessor's use only

C2a Show that the reactance of the capacitor is 270 Ω.

Basic	Level
Excellent	
Weak	
NR	

C2b Draw a clearly labelled phasor diagram showing the relationship between the reactance of the capacitor, X_c, the resistance, R and the impedance, Z.

Basic	Level
Excellent	
Weak	
NR	

C2c Show that the impedance of this circuit is 339 Ω.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

C2d Calculate the phase relationship between the supply voltage and current.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

Assessor's use only

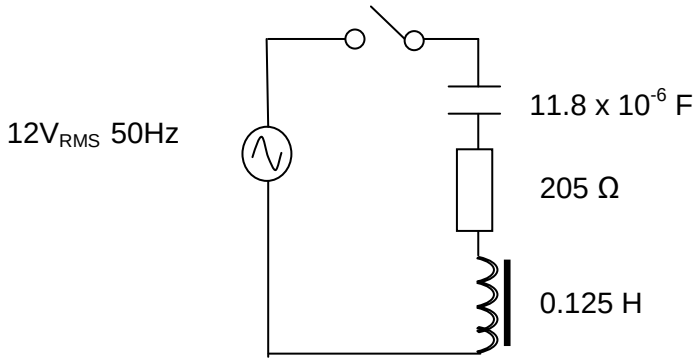
C2e

Calculate the rms current in the circuit.

Basic	Level
Excellent	
Weak	
NR	

C2f

Emma includes a 0.125 H inductor in the circuit as shown in the diagram.



Show that the reactance of the inductor in this circuit 39.3 Ω.

Basic	Level
Excellent	
Weak	
NR	

C2g

Show that the resonant frequency for the circuit is 131 Hz.

Basic	Level
Excellent	
Weak	
NR	

C2h

Explain how this circuit could be adjusted to bring it to resonance.

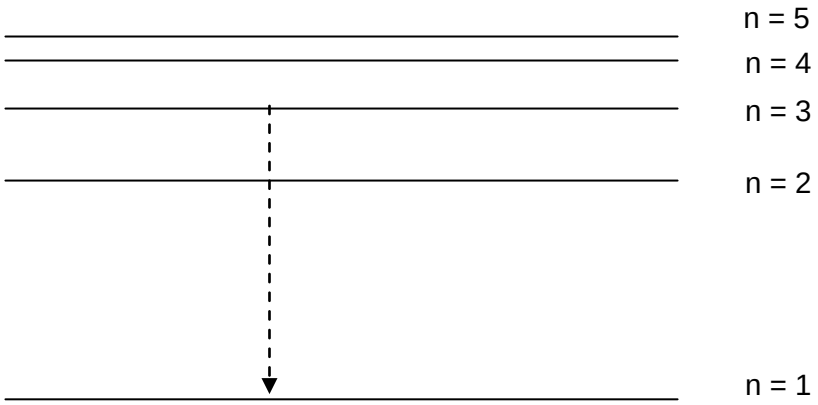
Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

SECTION D: ATOMIC AND NUCLEAR PHYSICS

(22 minutes)

D1 **THE BOHR ATOM**

Speed of light = 3.00×10^{8} m s^{-1}
Planck's constant = 6.63×10^{-34} J s
Rydberg's constant = 1.097×10^{7} m^{-1}
Some of the possible energy levels of the hydrogen atom electron are shown in the diagram below.



Assessor's use only

D1a In which part (UV, visible or IR) of the electromagnetic spectrum is the radiation emitted by the transition shown in the diagram?

Basic	Level
Excellent	
Weak	
NR	

D1b Show that the energy of the second excited state (n=3) is 2.42×10^{-19} J.

Basic	Level
Excellent	
Weak	
NR	

D1c The energy of the ground state (n=1) is 2.18×10^{-18} J. Show that the energy of the photon emitted when an electron undergoes a transition from the third quantum state to the ground state as shown in the diagram above is 1.94×10^{-18} J.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

D1d	Show that the frequency of the photon is 2.93×10^{15} Hz.	**Basic** / **Level** Excellent Weak NR
D1e	Show that the wavelength of the photon emitted by this transition is 1.03×10^{-7} m.	**Basic** / **Level** Excellent Weak NR
D1f	Explain which transition produces the red line in the visible part of the hydrogen atom emission spectrum.	**Proficient** / **Level** Excellent Moderate Weak NR
D1g	Determine the minimum energy required to ionise a hydrogen atom whose electron is in the ground state.	**Basic** / **Level** Excellent Weak NR
D1h	When light from a hydrogen gas discharge tube is looked at through a diffraction grating, a small number of discrete coloured lines are observed. Explain what causes the lines.	**Advanced** / **Level** Excellent Moderate Low Weak NR Exceed