MARKER CODE		Student Personal Identification Number

South Pacific Form Seven Certificate

PHYSICS

2016

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 Band			Weight /Time
	1 *Basic*	2 *Proficient*	3 *Advanced*	
PhyB: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in waves	**7 items**	**2 items**	**1 item**	**14%** 30min
PhyA: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in mechanics	**12 items**	**3 items**	**2 items**	**24%** 53min
PhyC: Demonstrate understanding, by explanation and solving problems, of the physical phenomena, concepts, principles and relationships involved in electricity and electromagnetism	**9 items**	**3 items**	**2 items**	**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 items**	**1 item**	**1 item**	**11%** 22min
TOTAL	**34 items**	**9 items**	**6 items**	**70% 150 min**

Check that this booklet contains pages 2-17 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 HARP**

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

The image above shows a harp. A harp is an instrument that is played by plucking the strings. One of the strings is 40.2 cm long.

Assessor's use only

A1a Calculate the wavelength of the fundamental standing wave produced.

Skill Level 1	
Basic	
Weak	
NR	

A1b In the space provided below sketch the third harmonic standing wave produced.

Skill Level 1	
Basic	
Weak	
NR	

Another string on the harp has a length of 62.3 cm and a mass of 3.32 x 10^{-4} kg. The tension in the string is 82.5 N. It can be shown that the speed of a wave produced on a string can be calculated using the formula:

$v = \sqrt{\frac{T}{\mu}}$ where T is the tension and μ is the mass per unit length.

A1c Show that the mass per unit length is 5.33 x 10^{-4} kg m^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

A1d	Show that the wave speed is 393 m s^{-1}.	**Skill Level 1** Basic Weak NR
A1e	During a concert the harp is played at the same time as a clarinet. A clarinet can be modelled as a pipe closed at one end of length 0.660 m. The largest wavelength sound produced by the clarinet is 2.64 m. Show that the lowest possible frequency note that could be played is 129 Hz.	**Skill Level 1** Basic Weak NR
A1f	Explain why the same note played on a harp sounds different to that played on a clarinet.	**Skill Level 2** Proficient Basic Weak NR

Emma is playing with a toy car that has a green light on top and a siren that produces a sound of frequency 312 Hz. When playing with the car, Emma notices that the frequency seems to change as the speed and the direction of the car changes.

Assessor's use only

A1g State the name given to this phenomenon.

_____

Skill Level 1	
Basic	
Weak	
NR	

A1h At one point the toy car is moving away from Emma. As the toy car slows down and stops Emma notices that the frequency changes. Explain the changes in frequency.

_____

_____

_____

_____

Skill Level 2	
Proficient	
Basic	
Weak	
NR	

A1i Show that the apparent frequency produced by the siren when the toy car is moving towards Emma at a speed of 6.50 m s^{-1} is 318 Hz.

_____

_____

_____

_____

Skill Level 1	
Basic	
Weak	
NR	

A1j Emma does not notice any change in the colour of the green light during the time she notices changes in the frequency of the sound. Explain.

_____

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_____

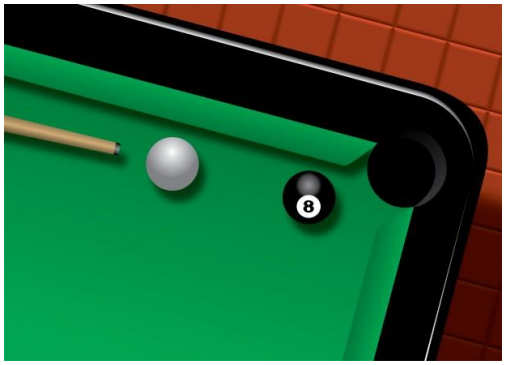
_____

Skill Level 3	
Advanced	
Proficient	
Basic	
Weak	
NR	

SECTION B: MECHANICS

(53 minutes)

B1 **THE POOL GAME**



Using a cue, a pool player hits a stationary white ball which slides without rolling towards a stationary black ball with velocity of 2.05 m s^{-1}, as shown in the diagram. Each ball has a mass of 0.160 kg.

Assessor's use only

B1a Show that the kinetic energy of the white ball is 0.336 J.

Skill Level 1	
Basic	
Weak	
NR	

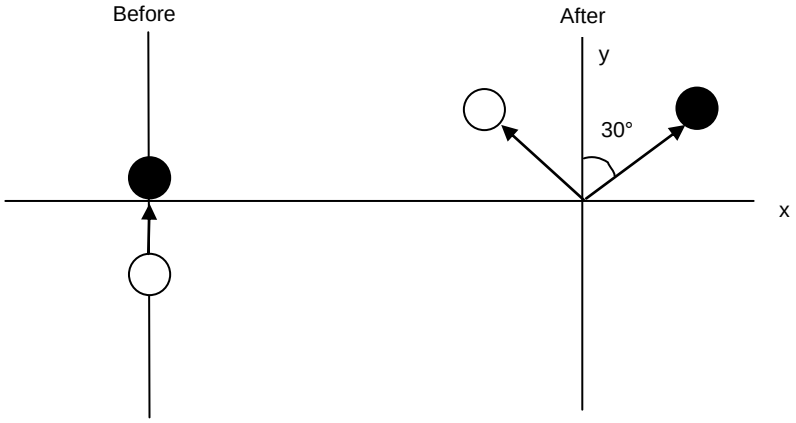
B1b Show that the change in momentum delivered by the cue on the white ball is 0.328 kg m s^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

B1c If the cue was in contact with the white ball for 0.295 s, calculate the magnitude of the average force exerted by the cue on the ball.

Skill Level 1	
Basic	
Weak	
NR	

Immediately after being hit by the white ball, the black ball slides without rolling with a velocity of 1.25 m s^{-1}. The situation is shown in the diagram below.



Assessor's use only

B1d After the collision, show that the momentum of the black ball in the y direction is 0.173 kg m s^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

B1e Show that the momentum of the black ball in the x direction, after the collision is 0.100 kg m s^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

B1f	Calculate the speed of the white ball after the collision.	**Skill Level 3** Advanced Proficient Basic Weak NR
B1g	Before it reaches the pocket, the black ball stops sliding and is rolling. Explain.	**Skill Level 2** Proficient Basic Weak NR

B2 **BANKED CURVES**

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

A couple of friends go on a car journey. While travelling at a speed of 35.0 km h^{-1}, they come to a banked corner where there is no friction between the tyres and the road. The radius of the corner is 60.0 m.

Assessor's use only

B2a Show that 35 km h^{-1} is equal to 9.72 m s^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

B2b Explain why it is possible for the car to travel round the corner despite the fact that there is no friction.

Skill Level 2	
Proficient	
Basic	
Weak	
NR	

It can be shown that the speed required to round a frictionless banked corner is $v = \sqrt{rgtan\theta}$ where r is the radius of the corner, g is the acceleration due to gravity and θ is the angle of corner makes to the horizontal ground (the banking angle).

B2c Show that the banking angle is 9.13° in the above situation to ensure the car rounds the corner.

Skill Level 1	
Basic	
Weak	
NR	

B2d State what will happen to the car if it travels slower than 35 km h^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

B3 **BUNGY JUMPING**

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

A student ties one end of a light rubber rope (the bungy) to their ankles and the other end is fixed firmly to a platform. The length of the bungy is adjusted so that the student stops their downward motion at the surface of a river. The unstretched length of the bungy is 21.0 m. The student's mass is 67.0 kg. The platform is 65.0 m above the river. In this situation the height of student can be ignored and the bungy can be considered to act as a spring.

Assessor's use only

B3a Show that at the surface of the river the student's loss of gravitational potential energy is 42700 J.

Skill Level 1	
Basic	
Weak	
NR	

B3b State where this energy has gone.

Skill Level 1	
Basic	
Weak	
NR	

B3c Using conservation of energy, show that the spring constant of the bungy is 44.1 N m^{-1}.

Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

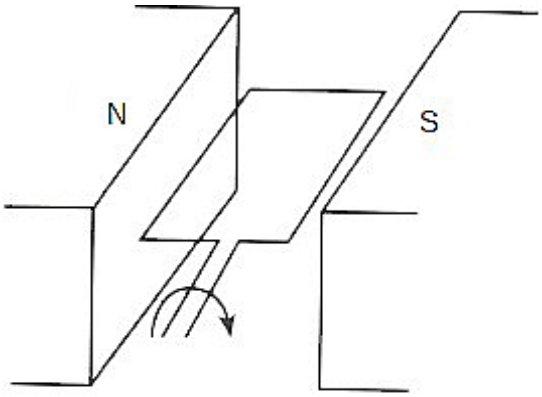
B3d	At some point on the jump, the student reaches a maximum speed. State the value of the net force acting when the student reaches this point. _____ _____	**Skill Level 1** Basic Weak NR
B3e	The distance below the platform at which the student reaches their maximum speed is 35.9 m. Using conservation of energy, show that the maximum speed is 23.6 m s^{-1}. _____ _____ _____ _____ _____ _____	**Skill Level 3** Advanced Proficient Basic Weak NR
B3f	At what position will the student experience the maximum upward acceleration? Explain your answer. _____ _____ _____ _____ _____	**Skill Level 2** Proficient Basic Weak NR

SECTION C: ELECTRICITY AND ELECTROMAGNETISM

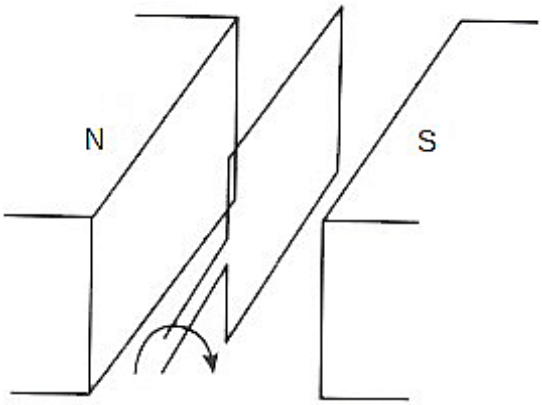
(45 minutes)

C1 **THE WIND TURBINE**

Wind turbine generators are used in various places around the world to generate electricity. A model of a simple generator is shown below. (For simplicity only one turn of wire is shown in the diagram.)



Position A



Position B

The magnets produce a uniform magnetic field of strength 0.275 T. The area of the loop in the magnetic field is 1.25×10^{-2} m^2.

Assessor's use only

C1a At which position A or B is the magnetic flux through the coil maximum?

_____

_____

Skill Level 1	
Basic	
Weak	
NR	

C1b Calculate the maximum magnetic flux through the coil.

_____

_____

_____

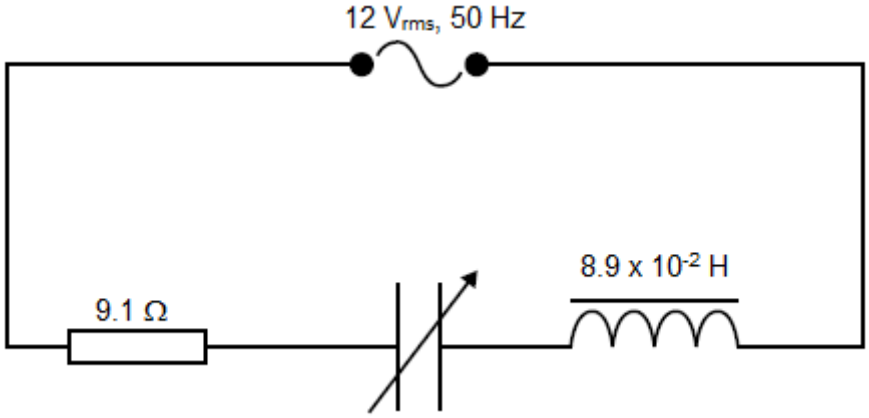
Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

C1c	The actual generator coil used has 600 turns of wire and is rotating at a frequency of 1.25×10^2 Hz. Explain, using energy ideas, how electricity is produced in a wind generator.	**Skill Level 3** Advanced Proficient Basic Weak NR
C1d	Show that the angular frequency of the coil is 785 rad s^{-1}.	**Skill Level 1** Basic Weak NR
C1e	Show that the maximum voltage produced by the coil is 1620 V.	**Skill Level 2** Proficient Basic Weak NR
C1f	Explain what is meant by the term rms voltage.	**Skill Level 2** Proficient Basic Weak NR
C1g	Calculate the rms voltage produced.	**Skill Level 1** Basic Weak NR

C2 **AC CIRCUITS**

It is often useful to alter the current in an AC circuit without changing the source voltage. An example of a possible circuit is shown below.



Assessor's use only

C2a Calculate the angular frequency of the supply.

Skill Level 1	
Basic	
Weak	
NR	

C2b Show that the reactance of the inductor is 28 Ω.

Skill Level 1	
Basic	
Weak	
NR	

C2c The current in the circuit is 0.36 A.

Show that the impedance of the circuit is 33 Ω.

Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

C2d	Calculate the reactance of the capacitor.	**Skill Level 2** Proficient Basic Weak NR
C2e	Explain how changing the capacitance affects the current in the circuit.	**Skill Level 3** Advanced Proficient Basic Weak NR
C2f	Show that the current in the circuit at resonance is 1.3 A.	**Skill Level 1** Basic Weak NR
C2g	State why the current is maximum when the circuit is at resonance.	**Skill Level 1** Basic Weak NR

SECTION D: ATOMIC AND NUCLEAR PHYSICS

(22 minutes)

D1 **THERMONUCLEAR REACTIONS**

Planck's constant = 6.63×10^{-34} J s
Rydberg's constant = 1.097×10^{7} m^{-1}
Speed of light = 3.00×10^{8} m s^{-1}

Mass of nuclei:
neutron: 1.67492×10^{-27} kg
proton: 1.67353×10^{-27} kg
lithium-6: 9.98835×10^{-27} kg

A thermonuclear reaction can take place between deuterium and tritium (isotopes of hydrogen). Tritium can be made from lithium ${}^{6}_{3}Li$, which can be extracted from rocks.

Assessor's use only

D1a Show that the mass deficit of a lithium nucleus is 5.700×10^{-29} kg.

Skill Level 1	
Basic	
Weak	
NR	

D1b Show that the energy released in the formation of lithium-6 is 5.13×10^{-12} J.

Skill Level 1	
Basic	
Weak	
NR	

Deuterium (hydrogen-2) can be extracted from water. Thermonuclear reactors heat a mixture of deuterium and tritium (hydrogen-3) to extremely high temperatures to produce the following reaction:

$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n $$

The amount of energy produced in this reaction is 2.82×10^{-12} J.

D1c Show that a photon of frequency 4.25×10^{21} Hz has an equivalent amount of energy.

Skill Level 1	
Basic	
Weak	
NR	

Assessor's use only

D1d	State why it is necessary for the temperature to be so high for this reaction to occur. _____ _____	**Skill Level 1** Basic Weak NR
	Nuclear reactions in the Sun produce light. The most abundant element in the Sun is hydrogen. The hydrogen spectrum can be observed by observing a hydrogen discharge tube. The following formula can be used to calculate the wavelengths of the lines produced by hydrogen: $\frac{1}{\lambda} = R\left(\frac{1}{S^2} - \frac{1}{L^2}\right)$ for visible light S=2.	
D1e	Show that the wavelength of the lowest frequency line in visible spectrum (L=3) is 6.56×10^{-7} m. _____ _____ _____	**Skill Level 1** Basic Weak NR
D1f	Describe how the light of this particular wavelength is produced. _____ _____ _____ _____	**Skill Level 1** Basic Weak NR

Assessor's use only

D1g	An electron transition from the sixth excited state (L=7) to the ground state occurs in two jumps. It releases a photon of wavelength 4.65 x 10^{-6} m. Calculate the wavelength of the second photon. _____ _____ _____ _____ _____ _____	**Skill Level 3** Advanced Proficient Basic Weak NR
D1h	The Sun emits all wavelengths. However, when the solar spectrum is observed on Earth some of the wavelengths are missing. Explain. _____ _____ _____ _____	**Skill Level 2** Proficient Basic Weak NR