Christ Church Grammar School

YEAR 12

PHYSICS STAGE 3

TRIAL EXAMINATION 2012

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1		
2		
3		
Total		/ 180 = %

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, eraser, correction tape/fluid, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, 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 notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

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	12	12	50	54	30%
Section Two: Problem-Solving	8	8	90	90	50%
Section Three: Comprehension	2	2	40	36	20%
				Total	100

Instructions to candidates

1. Write your answers in this Question/Answer Booklet

2. Working or reasoning should be clearly shown when calculating or estimating answers.

3. 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.

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

5. The Formulae and Data booklet is **not** handed in with your Question/Answer Booklet.

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Section One: Short Response

This section has **twelve (12)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **50 minutes**.

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Question 1 **(4 marks)**

Transperth B-series trains are capable of speeds up to 142 kmh^{-1} and are 2.90 m wide from wheel to wheel. Calculate the emf induced in the axle of such a train on the Joondalup line (travelling North) and state which side of the train would be at the higher potential. Assume the Earth's magnetic field in Perth is 5.50×10^{-5} T at 66.0° to the ground.

Question 2 **(4 marks)**

The compound **ninhydrin** is a fluorescent compound used to visualise fingerprints. Latent fingerprints are treated with the ninhydrin solution, which when illuminated with ultra violet light, turns the amino acid finger ridge patterns purple and therefore visible. Explain this phenomenon

Question 3 **(5 marks)**

You need to move a 50 kg bag of fertiliser from one end of the garden to the other. To assist you in your task you decide to use a wheelbarrow, as shown in the diagram below. Estimate the minimum magnitude of force that must be applied to the handles to lift the wheelbarrow (you can assume the bag of fertiliser has the same dimensions as the tray of the wheelbarrow). State clearly any estimations you make. Assume the mass of the wheelbarrow is 25 kg and the length from the handle to the centre of the wheel is 1.6 m.

Question 4 **(7 marks)**

Silicon films become better conductors of electricity when illuminated by infrared photons with energies of 1.14 eV or greater. This behaviour is called photoconductivity.

(a) What is the wavelength of these photons?

(4 marks)

(b) Could visible light also cause this photoconductivity? Explain your reasoning.

(3 marks)

Question 5 **(1 mark)**

According to the standard model of the fundamental particles, what is the same about quarks and leptons?

Question 6 **(3 marks)**

A lot of particles that are created through collisions of cosmic rays with particles in our upper atmosphere have very short lifetimes (e.g. muons). Many of these particles, however, can still be detected at sea level, even though their lifetimes would suggest that they should have decayed prior to reaching sea level. Explain why we are able to detect these particles.

Question 7 **(6 marks)**

The piccolo shown below has an air column of length 18.5 cm. When it is blown, the air column vibrates in its third harmonic at 2.70 kHz.

(a) What is the wavelength of the sound produced by the piccolo? Assume the piccolo is an open pipe. Include a diagram in your answer.

(3 marks)

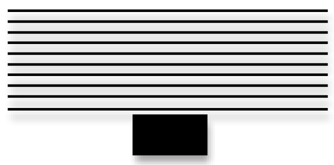
(b) What is the speed of the wave in the piccolo?

(3 marks)

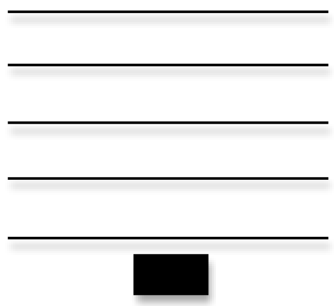
Question 8 **(4 marks)**

Complete these diagrams;

(a) **Light** incident on an object.



(b) Water waves incident on an object.

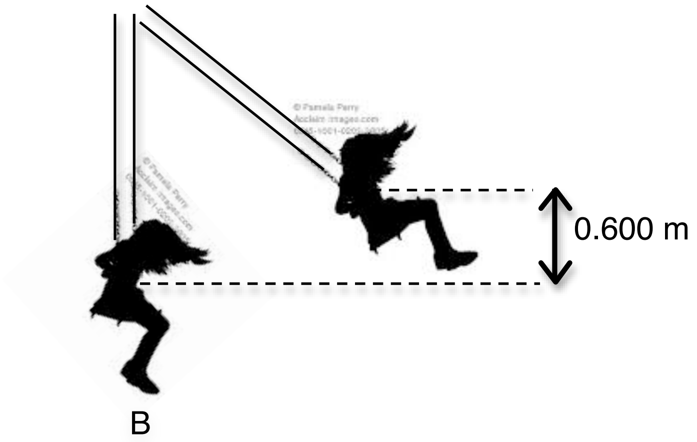


Question 9 **(4 marks)**

Explain why the classical Rutherford 'planetary' model of the atom predicts that atoms should collapse?

Question 10 **(6 marks)**

A child of mass 40.0 kg sits on a swing of negligible mass. The swing is pulled back so that the child's centre of mass is raised through a vertical height of 0.600 m as shown in the diagram below (diagram not to scale). The chain length is 3.20 m.



(a) Determine the speed of the child as she moves through position B.

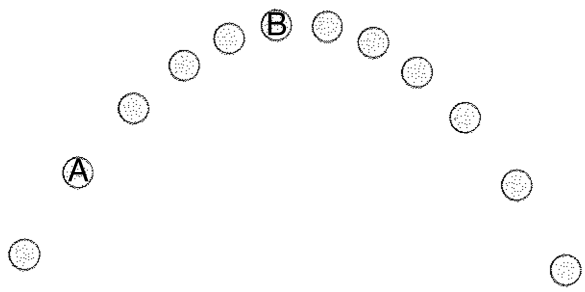
(3 marks)

(b) Determine the size of the normal force acting on the child as she moves through position B.

(3 marks)

Question 11 **(6 marks)**

The following questions refer to the diagram below which shows the motion of a ball undergoing projectile motion from the left to the right;



(a) Draw and label vectors to represent the acceleration and the velocity of the ball at points A and B.

(4 marks)

(b) Sketch the path of the ball if air resistance is now taken into account.

(2 marks)

Question 12 **(4 marks)**

If a motor is switched on and left to run with no load attached, the current flowing through the coil decreases. Explain why this is so.

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Section Two: Problem-Solving

This section has **eight (8)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **90 minutes**.

NAME:_______________________________________

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Question 1 **(10 marks)**

A car of mass 800 kg travels around a circular corner of radius 100 m at a speed of 50.0 kmh^{-1}.

(a) Determine the net force acting on the car.

(3 marks)

(b) Explain why curves are often banked to improve safety for motorists in wet or icy conditions.

(3 marks)

(c) Determine the angle at which this corner would need to be banked so that no friction is required for a car to travel around it at 50.0 kmh^{-1}.

(4 marks)

Question 2 **(11 marks)**

In the diagram below S_1 and S_2 are two water wave sources in a ripple tank. They are vibrating at the same frequency and amplitude. There is a maximum disturbance at A, a minimum at B, another maximum at C and so on. For each of the scenarios below state how will the pattern of maxima and minima will change.

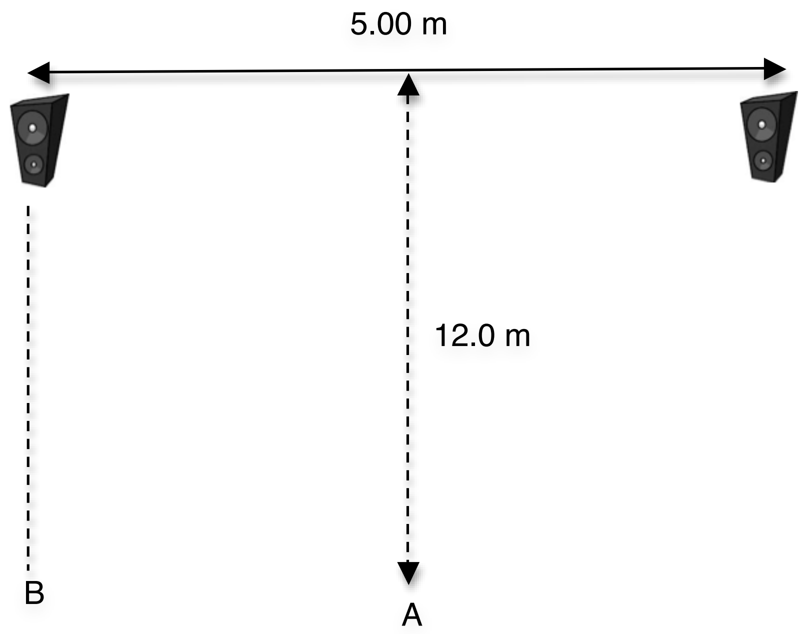
(a) The two sources are moved closer to each other.

(1 mark)

(b) The speed of the ripples is decreased (by reducing the depth of the water in the tank). Explain your reasoning.

(3 marks)

Two loudspeakers of a stereo system are separated by 5.00 m. They are connected to a single frequency generator and are placed so that face outwards as shown in the diagram below. The speakers are playing a frequency of 1000 Hz. Assume the speed of sound in air is 333 ms^{-1}.



(c) What would the person at A (midway between the two speakers) hear? Explain your reasoning.

(3 marks)

(d) If the person now moves to point B, what position would they be standing at? State whether it will be a loud or a soft spot and which number it will be.

(4 marks)

Question 3 **(10 marks)**

A physicist working in a laboratory wears a necklace enclosing 1.00×10^{-2} m^2 and with a resistance of 0.0100 Ω. The magnetic flux density in the laboratory starts at 2.00 T but due to a systems failure decays to 1.00 T in 1.00 ms.

(a) What is the current induced in the necklace?

(4 marks)

(b) What is the total power dissipated by the necklace?

(3 marks)

(c) What is the total energy transferred to the wearer's neck?

(3 marks)

Question 4 **(16 marks)**

The Hubble Law relates the recessional velocity of a galaxy and its distance from the Earth.

$$v = H_0 d$$

The redshift (z) of a galaxy is given by;

$$z = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$$

(a) Explain what is meant by the term 'redshift of a galaxy' and what is causing the redshift.

(3 marks)

A galaxy in the constellation Pisces is 5210 Mly from the Earth.
1 pc = 2.06 x 10^6 AU.

(b) Convert the distance to the constellation Pisces to Mpc.

(3 marks)

(c) Calculate the speed at which this galaxy is receding from Earth. Assume H_0 = 70 kms^{-1}/Mpc. If you could not answer (b) use a value of 140 Mpc.

(2 marks)

(d) What redshift ratio is expected for light from this galaxy?

(2 marks)

(e) Some galaxies in the Local Group (a group of about 30 galaxies that includes the Milky Way Galaxy, the Andromeda Galaxy and the Large and Small Magellanic Clouds) exhibit blueshifted spectral lines. Why is this so?

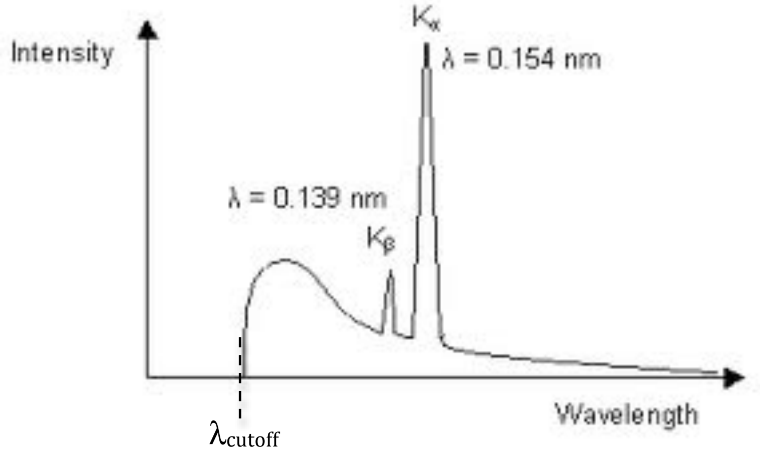
(3 marks)

(f) What three pieces of evidence suggest our Universe evolved from a 'Big Bang'?

(3 marks)

Question 5 **(10 marks)**

The figure below shows the spectrum of X-rays produced when a voltage source of 25.0 kV is used.



(a) Show on the diagram the position of the cut-off wavelength.

(1 mark)

(b) Determine the magnitude of the cut-off wavelength.

(4 marks)

(c) Explain the occurrence of the two distinct peaks on the spectrum.

(3 marks)

(d) If the operating voltage were to change, state **two** aspects of the X-ray spectrum that would also change.

(2 marks)

Question 6 **(12 marks)**

A transformer connected to a 240 V AC line is to supply 13.0 kV for a neon sign. To reduce the shock hazard, a fuse is to be inserted in the primary circuit. The fuse is to 'blow' when the current in the secondary circuit exceeds 8.50 mA.

(a) State whether a step-up or a step-down transformer should be used and calculate the ratio of turns in the transformer.

(3 marks)

- Step-up

(b) What power must be supplied to the transformer when the secondary current is 8.50 mA?

(3 marks)

(c) What current rating should the fuse in the primary circuit have?

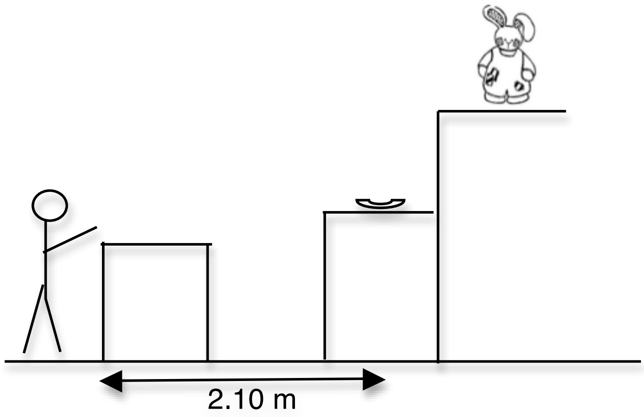
(3 marks)

(d) The transmission of power over long distances would not be economical without the use of step-up transformers. Explain why.

(3 marks)

Question 7 **(11 marks)**

In a stall at the Royal Show you can win a stuffed animal if you toss a 20 c piece into a small plate. The plate is on a shelf above the point where the 20 c piece leaves your hand and is 2.10 m horizontally from this point. If you toss the coin with a speed of 6.40 ms^{-1} at an angle of 60° above the horizontal, and the coin lands in the plate, determine;



(a) The time the coin is in the air for.

(3 marks)

(b) The height of the shelf above where the coin leaves your hand.

(3 marks)

(c) The velocity of the coin just before it lands in the plate.

(5 marks)

Question 8 **(14 marks)**

Soviet cosmonaut Major Yuri A. Gagarin was the first man to orbit Earth. In his spacecraft Vostok 1, Gagarin made a single orbit of the Earth on April 12, 1961. His flight lasted 1 hour and 48 minutes. The apogee (the farthest point in the orbit from Earth) was about 327 km above sea level and his orbital speed was 27.3×10^3 kmh^{-1}.

(a) Determine the acceleration due to gravity on Vostok 1 and Gagarin at the apogee of the orbit.

(3 marks)

(b) Choose one method to calculate the distance that Gagarin would have travelled had he remained at the orbit of 327 km above sea level for the duration of his flight.

(3 marks)

(c) Determine what the period of the orbit would have been if Gagarin had remained at the apogee for the entire orbit.

(4 marks)

(d) What does your answer to (b) tell you about the shape of Gagarin's orbit. Include a sketch in your answer and discuss changes in the speed of Vostok 1 in terms of its energy.

(4 marks)

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Section Three: Comprehension

This section has **two (2)** questions. Answer **all** questions. Write your answers in the space provided.

Suggested working time for this section is **40 minutes**.

NAME:_______________________________________

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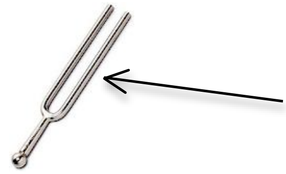
Question 1 **(19 marks)**

Tuning Forks

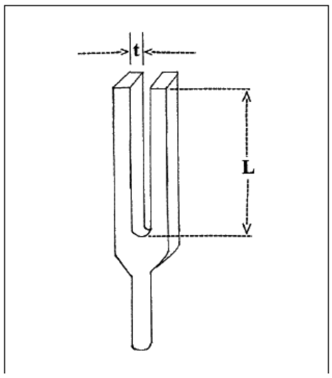
A tuning fork has two metal tines that flex alternately toward one another and away from one another.



The natural frequency of a vibrating system is determined by its physical shape and material of construction. In the case of a tuning fork, the length of the tines determines the natural frequency as well as the material of which it is made.

The equation that can be used to predict the fundamental resonant frequency of a tuning fork is given by;

$$f = \frac{(1.194)^2 \pi}{8L^2}\sqrt{\left(\frac{EK^2}{\rho}\right)} \quad - ①$$



Where, L is the length of the tines
E is Young's Modulus of the material
ρ is the density of the bar metal
K is the radius of gyration of the bar = $\frac{t}{\sqrt{12}}$
Where t is the thickness of the time.

The speed of sound in the bar, v, can be substituted for $\sqrt{\frac{E}{\rho}}$.

(a) Rewrite equation ①, substituting in v.

(1 mark)

A group of students conducted an experiment with a set of steel tuning forks to determine the values of m and B. They placed tuning forks of differing frequency near to a microphone connected to a cathode ray oscilloscope. They then struck each of the tuning forks in turn with a small rubber mallet.

The tuning forks used were all made from stainless steel and had a tine thickness (t) of 1.00 cm.

The period of each tuning fork was then measured from the oscilloscope screen. The results from this experiment are given below.

L (m)	f (Hz)	
0.19	261	
0.17	330	
0.16	392	
0.15	440	
0.13	523	

(b) Process the collected data so you are able to plot a graph of;

$$f \text{ vs } \frac{1}{L^2}$$

(2 marks)

(c) Plot a graph of $f \text{ vs } \frac{1}{L^2}$ including a line of best fit.

(5 marks)

(d) Determine the gradient of your graph.

(3 marks)

(e) Use your answer from (d) to determine the value of v, the speed of sound in the stainless steel tuning fork.

(3 marks)

(f) The accepted value for the speed of sound in stainless steel is 5800 ms^{-1}. Determine the percentage error in your result.

(2 marks)

(g) Explain why tuning forks with long tines will vibrate at lower frequencies than short-tined forks?

(3 marks)

Question 2 **(15 marks)**

Mechanical Oscillations and Resonance in a Tuning Fork

Standing waves can also be set up in rods and plates (as well as in strings and pipes). The sound from a tuning fork is produced by the vibrations of each of its tines. A tuning fork can be made to sound be striking it with a rubber mallet, in which case it will oscillate at its natural frequency **or** can be forced to oscillate at the same frequency as an external source by physically moving the tines in and out.

(a) In the second scenario for making the tuning fork oscillate, what condition must be met for the tuning fork to have large amplitude oscillations (i.e. to resonate)?

(1 mark)

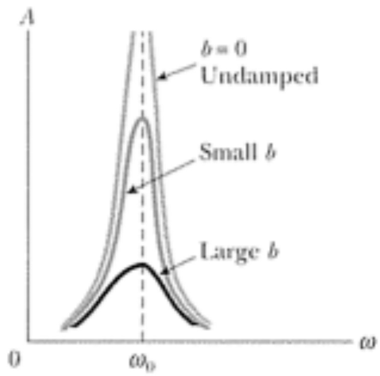
In everyday life, we often see damped oscillatory motion. Examples are the swinging of a pendulum, the bouncing of a car's front-end suspension (particularly visible if the `shocks' are worn out), the vibration of a string of a guitar. In these real systems, dissipative forces, such as friction, retard the motion. Consequently, the mechanical energy of the system diminishes in time and the motion is said to be **damped**.

One common type of retarding force is where the force is proportional to the speed of the moving object and acts in the direction opposite to the motion. This retarding force (R) is often observed when an object moves through the air and can be expressed as;

$$R = -bv$$

Where b is a constant called the damping coefficient.

When a resonant system (such as an oscillating tuning fork) is damped, the shape of the resonance curve will change as shown in the diagram below (ω is a symbol used for frequency);



(b) State and sketch a diagram to show how you would expect the frequency and amplitude of a sound wave to change if its source is damped.

(3 marks)

(c) Explain why the shape of the resonance curve depends on the damping coefficient by making reference to energy transfer during resonance.

(2 marks)

(d) If a tuning fork were struck in the vacuum of space, would you expect damping to occur?

(2 marks)

Experiments to determine the nature of damping for a resonant system are often performed with large tuning forks, in which two massive prongs can vibrate towards and away from each other, as shown in the diagram below.

(http://www.faraday.physics.utoronto.ca/IYearLab/tunfk.pdf)

A ferrite (iron) magnet is placed on the end of one prong of the tuning fork, which moves with the prong in front of a coil of wire, which is connected to an ammeter. This coil is referred to as the 'pick-up' coil and is used to determine the speed of oscillation of the tuning fork.

(e) Explain how the magnet and 'pick-up' coil system would be used to determine the speed of oscillation of the tuning fork.

(3 marks)

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The tuning fork can also be damped additionally by mounting a plate of copper to the other prong of the fork (not the one with the magnet on it). The copper plate can then be surrounded by an external magnet.

(f) Explain how the inclusion of the copper plate and magnet setup would increase the damping of the tuning fork.

(4 marks)

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