NATIONAL SENIOR CERTIFICATE EXAMINATION
EXEMPLAR 2008

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 14 pages
   - a data and formula booklet of 3 pages (i – iii)

   Make sure that your question paper is complete.

2. Remove the pages of data and formulae from the middle of this question paper.

3. Use the data and formulae whenever necessary.

4. Read the questions carefully.

5. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1 GAUTRAIN

Computer-modelled images of the trains as they might appear

You are a passenger on the first trip of the Gautrain. You board at Park Station on a non-stop trip to Pretoria. The following announcement is made:

'Welcome aboard the Gautrain Electrostar. The motors will exert a resultant (net) force of 35 kN to accelerate the train at 0,5 $m.s^{-2}$ from rest to its cruising speed of 40 $m.s^{-1}$. Please ensure that you are seated **while train is accelerating.**'

1.1 Convert 40 $m.s^{-1}$ to $km.h^{-1}$. (2)

1.2 Calculate the magnitude of the displacement of the train during its acceleration. (3)

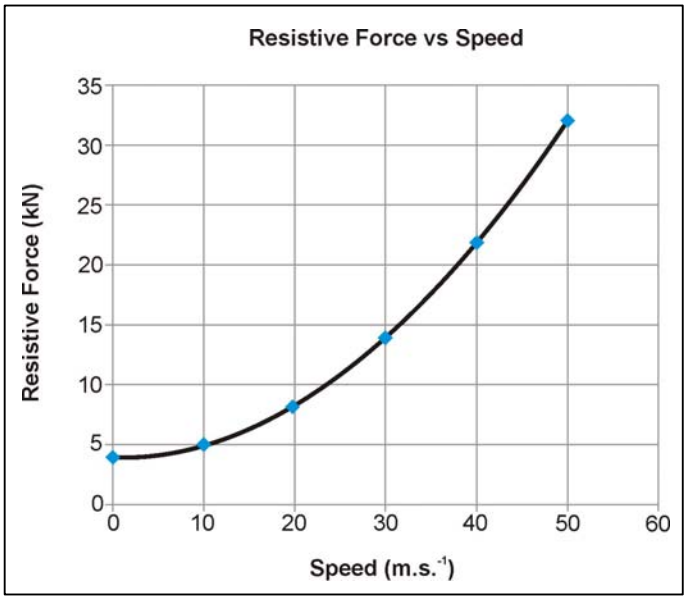
1.3 The acceleration of the train takes place over a straight track.

1.3.1 State the work-energy theorem. (2)

1.3.2 Use the work-energy theorem to calculate the kinetic energy of the train when it reaches its cruising speed of 40 $m.s^{-1}$. (3)

1.4 Explain whether it is necessary to ask the passengers to be seated **while the train is accelerating.** Refer to a law of physics or to your knowledge of frames of reference to justify your answer. (2)

The train has reached its cruising speed of 40 m.s^{-1} and you begin reading through the Gautrain information brochure that contains the following graph of Resistive Force vs Speed:



1.5 **Use the graph** to estimate resistive force on the Gautrain when it travels at 40 m.s^{-1}. (1)

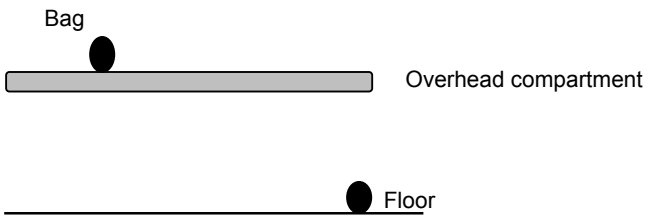
1.6. Calculate the power that the engine produces to pull the train at this speed. (3)

1.7 Use the map of the train's route to estimate the distance travelled by the train from Malboro to Centurion. (Hint: There is a scale shown on this map). (1)

1.8 Calculate the time taken to pull the train from Marlboro to Centurion if the Gautrain maintains its cruising speed. (3)

ANSWER EITHER OPTIONAL QUESTION 1.9 OR OPTIONAL QUESTION 1.10

1.9 When you get to Centurion the announcer tells passengers to go back to their seats because the train has to slow down suddenly. As a result of this a bag falls to the floor from the overhead compartment. The bag travels forward as it falls and it lands on the floor of the train at the mark shown in the diagram below.



1.9.1 Explain why the bag travelled forward as the train slowed down. (2)

You consider that the greater the rate at which the train slows down, the greater the distance the bag will travel forward relative to the train. The only apparatus you have at hand is a metre rule and a digital accelerometer (a device that measures acceleration in $m.s^{-2}$).

1.9.2 Which measurement(s) would be necessary to investigate this hypothesis? (2)

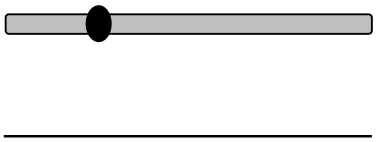
1.9.3 Explain briefly how to investigate this hypothesis. (3)

ANSWER QUESTION 1.10 IF YOU HAVE NOT ANSWERED QUESTION 1.9

(OPTIONAL)

1.10 While the train is moving at its cruising speed of 40 $m.s^{-1}$ a bag falls to the floor of the train from the overhead compartment. It takes 0,6 s to reach the floor of the train.

1.10.1 Copy the diagram below into your answer book, and draw **the path of the bag as observed by a passenger seated alongside it** in the train. (2)



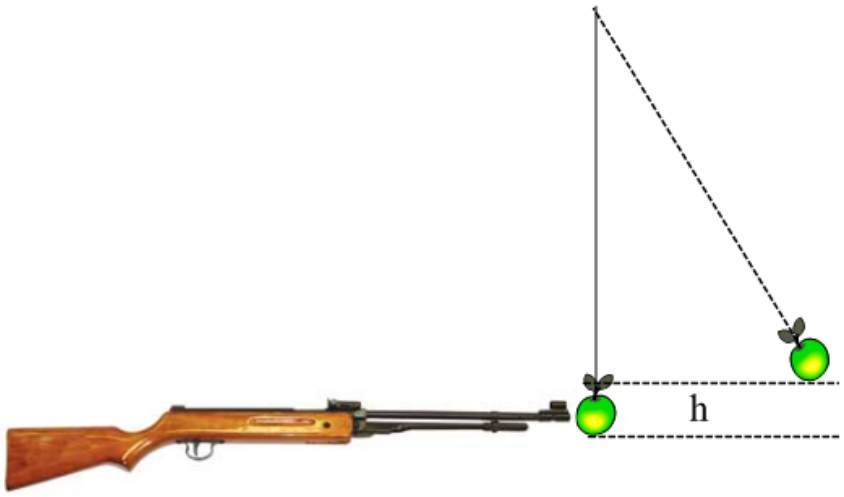
1.10.2 Calculate the height of the bag above the floor. (2)

1.10.3 How would the path of the bag change if the train slowed down suddenly when it fell to the floor? Use a sketch to show the path of the bag, and briefly explain why this happens. (3)

27 marks

QUESTION 2 BALLISTIC EXPERIMENT

NB: This experiment was carried out in an open field alongside a high brick wall for safety reasons.



A Physics student decides to investigate how the impact speed of a pellet fired from his air rifle is affected by the distance from the target. He decides to fire the pellet gun at an apple which is suspended from a light string. The pellet gets stuck in the apple when it is fired. The apple and the pellet swing away to the right, as shown in the diagram, to a certain height, h.

By using laws of Physics, he can calculate the velocity of the pellet when it hits the apple (i.e. the impact speed). The mass of the pellet is 1,0 g and the mass of the apple is 100 g.

He repeats the experiment increasing the range by 5 m each time until the range is 20 m.

2.1 State the principle of conservation of momentum. (3)

2.2 State the principle of conservation of energy. (3)

2.3 When he fired at the apple from point blank range, the height gained was 15 cm. Calculate the speed of the apple plus pellet immediately after impact. (4)

2.4 Calculate the impact speed of the pellet. (4)

2.5 Write a hypothesis for this experiment. (1)

2.6 Identify the following variables for this experiment:

2.6.1 the independent variable. (1)

2.6.2 the dependent variable. (1)

2.7 Suggest how he can measure the height to which the apple swings. Explain briefly. (3)

2.8 Pellet guns and catapults are dangerous weapons when used in towns or villages. The minimum kinetic energy to pierce skin is 2 J.

Pellet gun

Catapult

Consider the following facts about a pellet gun and a catapult when fired from 20 m.

	Mass (kg)	Impact speed ($m.s^{-1}$)
Catapult (stone)	0,01	15
Pellet gun (pellet)	0,001	150

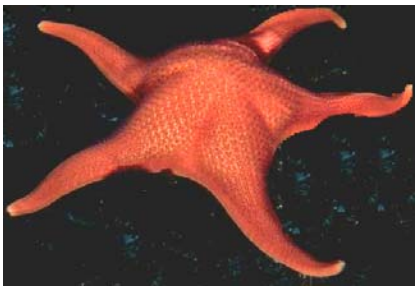
2.8.1 Compare the momentum of the stone and the pellet. (3)

2.8.2 Should either or both of these weapons be banned from use in towns and villages? Justify your answer with calculations and scientific facts. (7)

30 marks

QUESTION 3

3.1 OPTICAL ILLUSIONS?



A **Red** Starfish washes up on the beach. Some children rescue it and put it into a **yellow** bucket. They add some seawater to the bucket to keep the starfish alive. They stare at the starfish through the water in the bucket from above.

3.1.1 Calculate the frequency of the 650 nm red light coming from the starfish. (4)

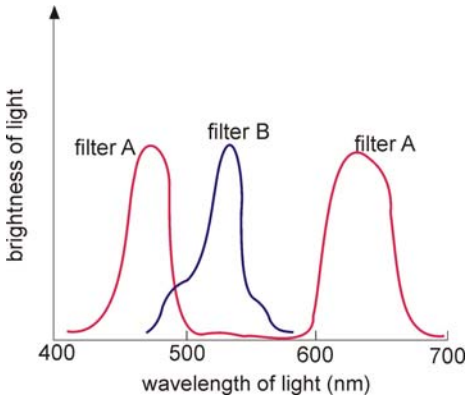
3.1.2 Name the phenomenon which causes the starfish to appear to be shallower than it really is when viewed from above through the water in the bucket. (1)

The children rush over with the bucket to their parents to show them the starfish. Their parents are each wearing different types of sunglasses.

Their father is wearing sunglasses made of filter A. Their mother's sunglasses are made of filter B.

Colour	Wavelength (nm)
Red	750-630
Orange	630-600
Yellow	600-560
Green	560-490
Blue	490-420
Violet	420-400

The table shown above gives the colour of light of different wavelengths.



This graph gives the brightness of light which each of filter A and B allows through.

3.1.3 What colour(s) of white light are transmitted through their father's sunglasses? (4)

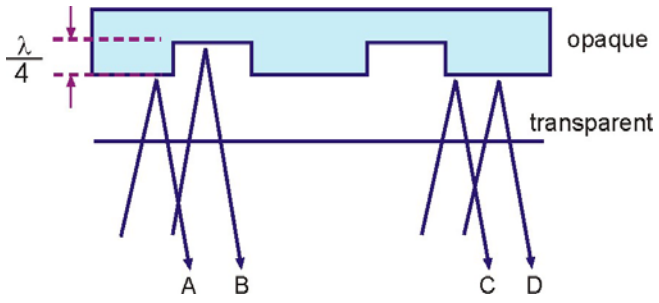
3.1.4 What **colour** does their father's sunglasses appear to be in white light? (2)

3.1.5 Their mother claims that it is not a **red** starfish in the bucket at all. Explain briefly, and state what colour the starfish appears to be to her. (3)

[13]

3.2 HOW A CD WORKS

A compact disc (CD) is a sandwich of two plastic layers. The upper layer is opaque and is pressed with a series of bumps and pits. The undersurface is coated with a thin layer of reflective aluminium. The lower layer is a transparent polycarbonate (plastic) about 1,2 mm thick.



The interference of light is a critical part of the operation of compact discs (CDs).

When a CD is read, a laser beam is directed upwards from underneath the CD. The reflected beam interferes with the incident beam. The resultant beam is detected by an electronic sensor, which produces a digital signal based on the intensity (brightness) of the resultant beam.

If the reflected rays are in phase with the incident beam (e.g. C and D), they will reinforce each other, and the reflected beam will be bright enough to register a '1' on the detector.

If the two rays are exactly out of phase (e.g. A and B) a '0' will be registered on the signal detector. This occurs when some of the light reflects from within a pit.

3.2.1 Explain the difference between 'opaque' and 'transparent'. (1)

3.2.2 Name the principle on which interference of light occurs. (1)

3.2.3 What name do we give to the phenomenon of waves which interfere to reinforce each other? (1)

3.2.4 Explain why rays A and B are exactly out of phase. (1)

3.2.5 Draw a diagram to show why rays which are exactly out of phase with each other register a '0' on the signal detector. (2)
[6]

ANSWER EITHER OPTIONAL QUESTION 3.3 OR OPTIONAL QUESTION 3.4

3.3 THE ANNOYING MOSQUITO

A mosquito flaps its wings at 600 vibrations per second which produces the annoying buzz. The speed of sound in air is 340 $m.s^{-1}$.

3.3.1 What is the frequency of the buzz generated by the mosquito's wings? (1)

3.3.2 Calculate the wavelength of the mosquito's buzz. (3)

3.3.3 How would you know from the sound of its buzz whether the mosquito is flying towards you as you lie in bed in a dark room? (2)

3.3.4 Name the effect that changes the sound of the mosquito's buzz as it flies towards you. (2)

After a few more minutes the sound of the mosquito's buzz changes to 598 Hz even though it is still flapping its wings at 600 vibrations per second. You are lying still in your bed in the dark room.

3.3.5 Calculate the speed of the mosquito relative to you when you hear the sound at 598 Hz. (5)

3.3.6 Is it good or bad news for you that the sound has changed to 598 Hz? Explain briefly. (3)

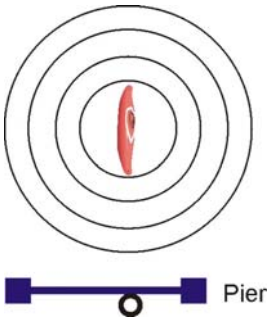
3.3.7 Draw a sketch showing the compressions of the air made by the mosquito flying at this velocity relative to you. (4)

[20]

ONLY ANSWER THIS QUESTION IF YOU LEFT OUT QUESTION 3.3

(OPTIONAL)

3.4 THE MOTOR BOAT



A boat is anchored in a dam in calm water. Small ripples come from the boat as its motor idles.

An observer (O) on a pier notices that the crests of the ripples from the boat pass him every 5 s. He estimates the distance between the crests to be 10 m.

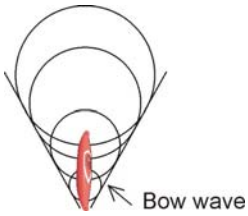
3.4.1 Calculate the speed at which the ripples travel outwards. (4)

The driver of the boat lifts the anchor and applies a little power to its motor. The boat moves slowly along the water towards the stationary observer.

3.4.2 Draw a sketch showing the pattern of crests made on the water. (3)

3.4.3 Describe how each of the following has changed or remained the same in the ripples between observer O and the boat.

(a) wavelength (1)
(b) frequency (1)
(c) speed of the crests in the water (1)



The driver increases the speed of the boat and the crest pattern looks like this, as shown in the diagram alongside.

Instead of the steady ripples passing the observer, a large 'bow wave' suddenly passes under the pier.

3.4.4 What is the minimum speed of the boat now? (2)

3.4.5 Use the concept of interference to explain the occurrence of the bow wave. (2)

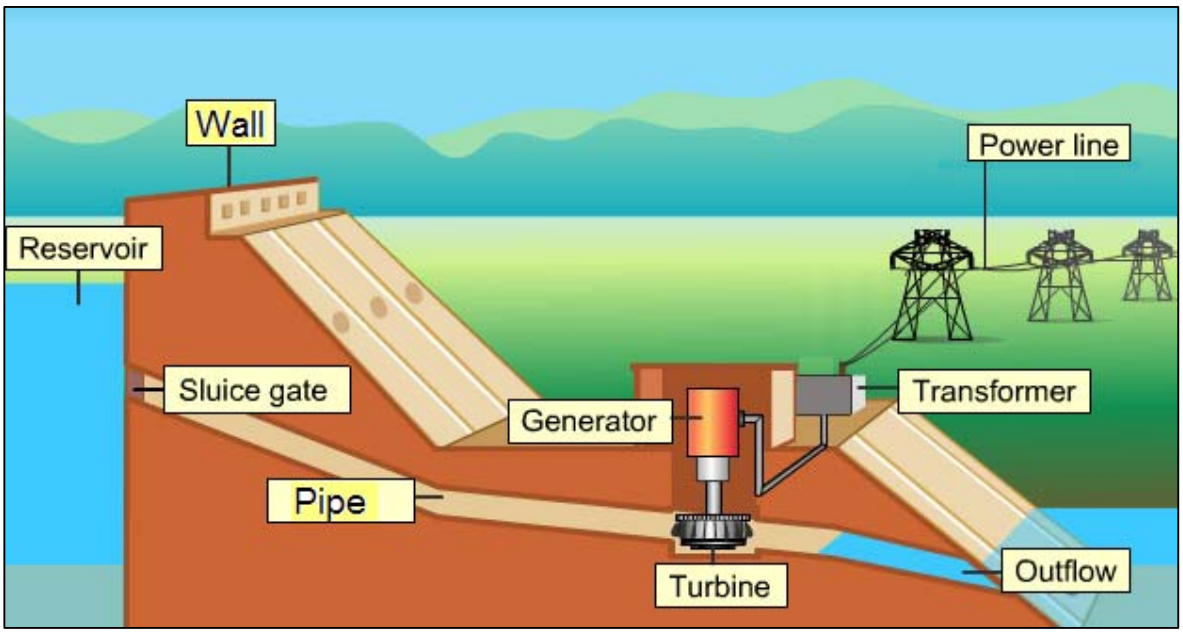
3.4.6 Give three differences between the bow wave seen here and the sonic boom experienced when a supersonic fighter plane passes overhead. (3)

3.4.7 Predict how the pattern changes if the captain increases his speed further. (3)

[20]

39 marks

QUESTION 4 GENERATING ELECTRICITY



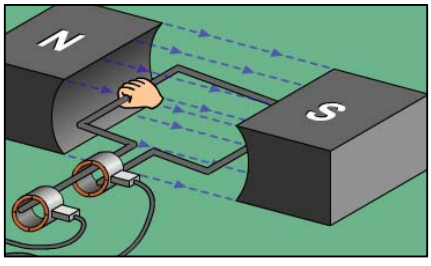
A fruit farmer in the Barkley East area is fed up with Eskom's power cuts. He designed a hydro-electric generating system to keep his electrical appliances operating correctly. The electrical energy will be used in the drying shed some distance away from the dam wall. He has installed a power line consisting of two cables with the appropriate transformers to deliver the energy efficiently.

4.1 An energy flow diagram showing the energy transfers in the system might start like this:

In the pipe		In the turbine		In the generator		In the transformer
Ep water → Ek water	→	4.1.1	→	4.1.2	→	4.1.3

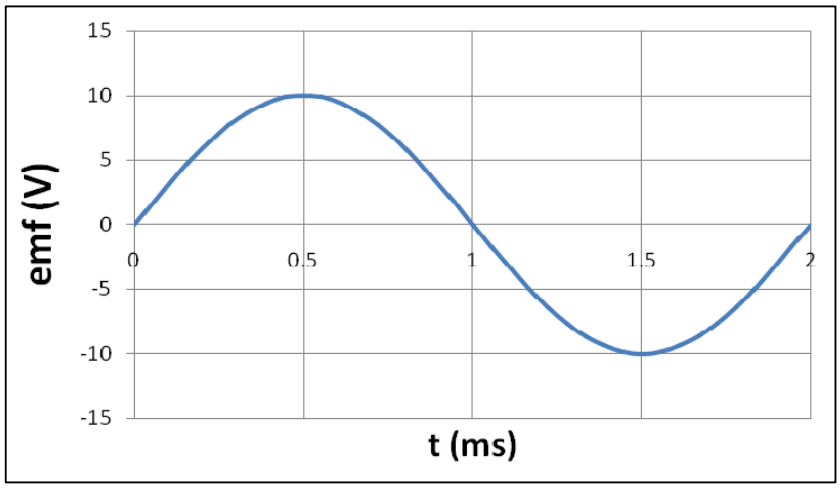
Complete the diagram showing the energy transfers in **the turbine**, in **the generator** and in the **transformer**. (6)

4.2 The diagram below shows how an a.c. generator works. This generator is being turned clockwise.



Using Faraday's Law, explain how this generator works. (5)

The output of the a.c. generator which is being turned **clockwise** is shown below.



4.3 Use the graph of output voltage against time to estimate the time (in ms) which corresponds with the output voltage of this a.c. generator when it is in the position shown (in the diagram for Question 4.2). (2)

4.4 If the rate of turning the coil is **doubled**, how will the output of the generator change? Copy the graph of voltage against time into your answer book, and draw the corresponding graph for the output voltage of the generator on your copy of the original graph. (3)

4.5 Name three ways in which the emf of the generator can be increased. (3)

ANSWER EITHER OPTIONAL QUESTION 4.6 OR OPTIONAL QUESTION 4.7

4.6 How does an a.c. generator differ from a d.c. generator in voltage output and in construction? (3)

ANSWER THIS OPTIONAL QUESTION IF YOU DID NOT ANSWER OPTIONAL QUESTION 4.6

4.7 Calculate the V_{rms} value for this demonstration generator. (3)

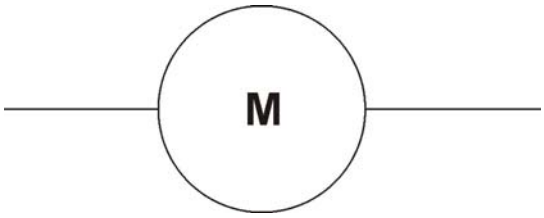
22 marks

QUESTION 5 THE DRYING SHED

The climate in Barley East is cold and wet, so the farmer blows air over the fresh fruit to help it dry out faster. He decides to use four fans driven by 1000 W a.c. motors to help speed up the drying process. The motors run 24 hours per day.

5.1 Draw a circuit diagram showing the 4 motors for the four fans all operating off 240 V a.c. Include a main switch as well as a switch to control each motor independently.

Use this symbol to show that it is an a.c. motor.



(4)

5.2 Describe the energy transfers that are taking place in the motors. (2)

5.3 Calculate the energy the drying system uses in a day in kW.h, when operating at full power. (3)

5.4 The farmer finds two old fans lying around in the shed. The labels on their motors read 120 V d.c, 80 W. He wants to use these two fans in a far corner of the shed to improve the air circulation.

5.4.1 What does the label 120 V d. c, 80 W mean? (3)

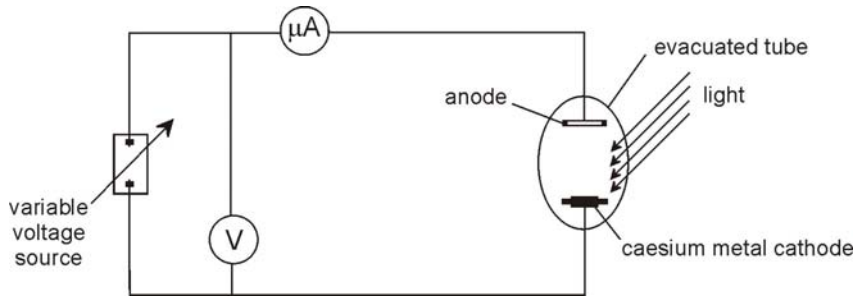
5.4.2 Use your knowledge of diodes to design a basic circuit to operate these two old d.c. fans from the a.c. power supply. (4)

16 marks

QUESTION 6 MATTER AND MATERIALS

A photoelectric cell is connected into a circuit. The lowest frequency of light that will emit electrons from its caesium surface is 5,1 x 10^{14} Hz.

Violet light of wavelength 400 nm is incident on the caesium surface.



6.1 What is the threshold frequency of a metal? (2)

6.2 What is the difference between a photon and a photoelectron? (2)

6.3 Calculate the work function of caesium. (2)

6.4 Calculate the amount of energy carried by the incident photons of violet light? (4)

6.5 Calculate the kinetic energy of the fastest photoelectrons emitted from the caesium surface when violet light shines on it. (3)

6.6 Give one application which makes use of the particle nature of light. Explain briefly. (2)

15 marks

TOTAL FOR THIS PAPER: 150 MARKS